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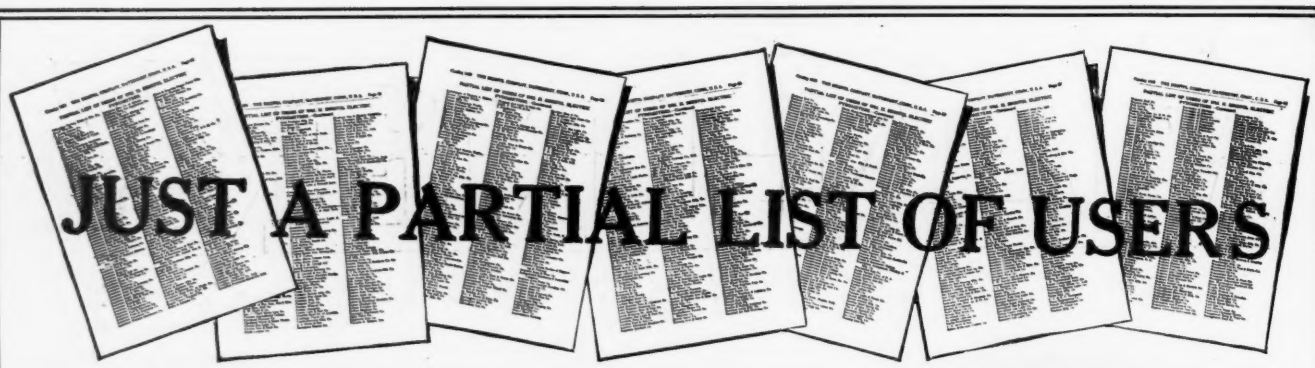

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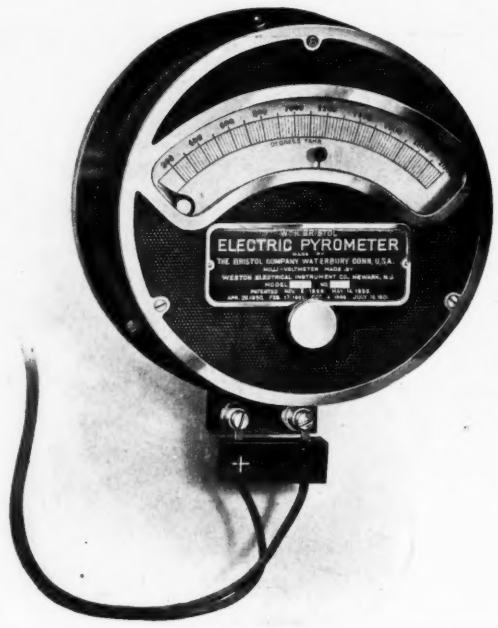

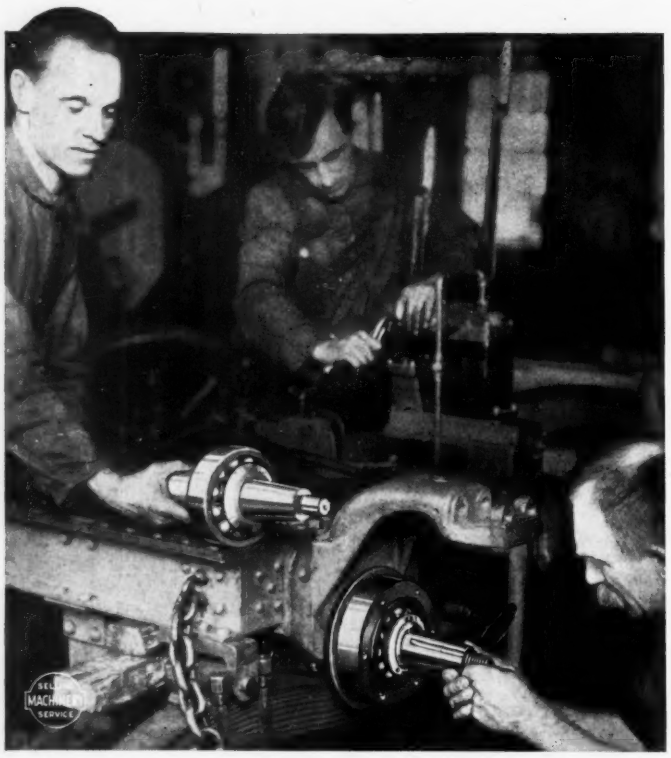

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VANADIUM

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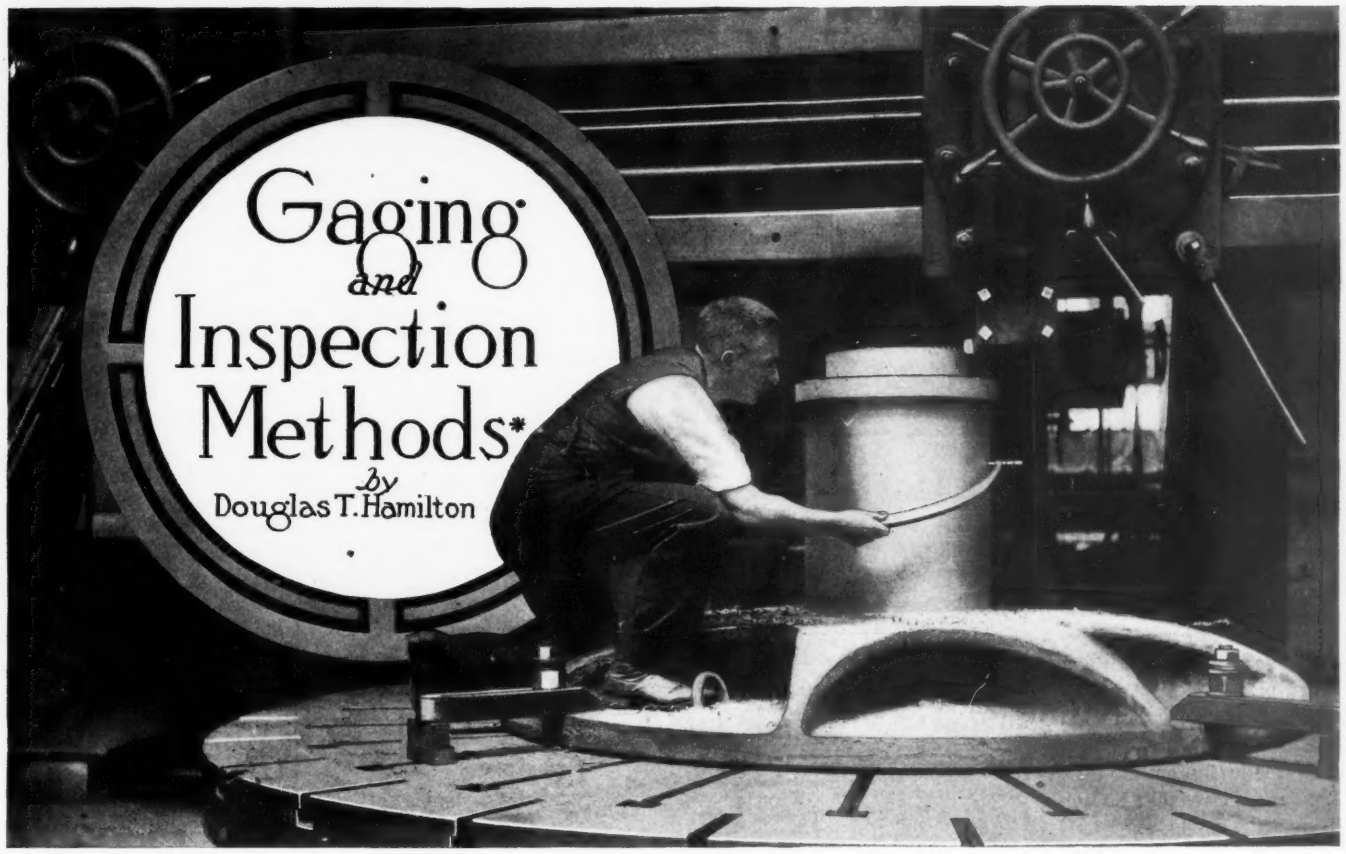


The importance of gages and inspection methods in modern interchangeable manufacturing is generally recognized, and at this time, when manufacturing industries are rapidly expanding, a review of gages and gaging methods is especially timely. The limit system is the foundation or basis of interchangeable manufacturing, and in these articles the author has undertaken to make clear the matter of limits, allowances and tolerances. Various types of gages are used to illustrate. The article takes up the developments of interchangeable manufacture, the limit system, advantages of the limit system, difference between allowance, tolerance and limit, setting manufacturing limits on interchangeable parts, various methods of establishing a system of limits, simple method of establishing manufacturing limits, allowances for various classes of fits, establishing allowances and tolerances for various classes of fits, and various methods of presenting manufacturing limits on drawings. Very little data are available on the life of gages, and in this article, references are given to records which indicate the probable life of gages on certain classes of work and material, and the advantages to be obtained by giving manufacturing tolerances on gages to provide for wear. These data are of much value to those who have to estimate on large quantities of work, such as munitions and shells that are made in great quantities.

PREVIOUS to the adoption of gages and inspection fixtures, the component parts of mechanisms were made by fitting one to another. As an illustration, we will take a gasoline engine and assume that the cylinders were finished by reaming. The pistons would be made approximately to size by caliper measurements and then fitted to the bore of the cylinders, the cylinders acting as a gage. In this way, of course, the production of interchangeable parts is difficult if not impossible. The question of having each part alike within given limits, however, has not always been considered practical or necessary, and the first application of the interchangeable system was adopted in the production of rifles, as will be described later.

In the past few years the subject of gaging and inspection methods has received considerable attention. This has been due more particularly to the desire to reduce manufacturing costs rather than to have all parts made interchangeable. For instance, in the manufacture of the modern automobile, which is one of the many examples of interchangeable manufacture, it makes very little difference to the purchaser, generally speaking, whether the parts are interchangeable or not, but it does make a great difference to the manufacturer who is desirous of reducing his manufacturing costs to a minimum. In order to accomplish this it is necessary to employ efficient gaging and inspection methods, so that the time spent by the operator in measuring the work will be greatly reduced.

It has also been clearly demonstrated in plants where the interchangeable system has been properly applied that a poorer grade of mechanics can be employed and still turn out interchangeable parts. It requires the services of a first-class mechanic to make a number of parts exactly alike, without a gaging system, but a poor mechanic can make a large number of parts exactly the same—within the required limits—and much cheaper, with a proper gaging and inspection system. Hence, the chief advantage gained by interchangeable manufacture is not that all parts are made alike, but that production costs are greatly reduced.

* For articles on gages and gaging previously published in MACHINERY, see "Fixed Caliper Gages in Manufacturing," May, 1916; "Plug and Ring Gage Allowances," January, 1916; "Limit Gage with Ball Contact Points," January, 1916; "High-explosive Shell Cartridge Cases," December, 1915; "Interchangeability," August, 1915; "Rogers Taper-end Plug Gages," July, 1915; "Ames Test Gage," June, 1915; "Taft-Peirce Tool-room Specialties," June, 1915; "Thread Tool Gages," June, 1915; "How We Came to Have the Micrometer Caliper," June, 1915; "B. & S. Machinists' Small Tools," May, 1915; "Shrapnel and Shrapnel Manufacture—Gaging Shrapnel Shells," April, 1915; "Slocomb Bench Micrometer," March, 1915; "Limit Gage for Measuring Recessed Work," January, 1915; "Slocomb Direct-reading Micrometer," December, 1914; "Thread Measuring Tool," November, 1914; "Precision Method of Measuring Angles," October, 1914; "Checking a Cam-shaft with the Dial Indicator," August, 1914; "A Dial Comparometer," August, 1914; "One-wire System for Measuring Threads," July, 1914; "A Gage Limit System for General Work," June, 1914; "The Use of Gages," June, 1914; "Gage for U. S. S. Thread Tools," April, 1914; "Gaging Watch Escapements," February, 1914; "Test Gages for Automobile Cylinders," January, 1914; "Measuring the Flat on U. S. and Acme Thread Tools," July, 1913; "Atlas Ball Gages," May, 1913; "A 'Three Point' Micrometer and Its Use," May, 1913; "Fixtures and Gages used in Manufacturing the Multigraph," April, 1913; "Measuring Screw Threads by Means of Micrometers," January, 1913; "Ashcroft Thickness Gage for Sheet Materials," November, 1912; "Making New Departure Ball Bearings," November, 1912; "Limits on Gearing," October, 1912; "A Ball Race Gage," July, 1912; "Watch Movement Manufacture," June, 1912; "Device for Testing and Measuring Gears," April, 1912; "Taps and Tapping," April, 1912; "The Manufacture of Steel Balls," April, 1912; "Table of Allowances and Limits," April, 1912; "The Ross Rifle and Its Manufacture," January, 1912; "Plant Inside Micrometer Caliper," November, 1910; "A System of Gages for Small Parts," November, 1910; "Locating Work by the Button Method," October, 1910; "Height Gages for Inspecting," September, 1910; "Depth Gage with Indicator Attachment," September, 1910; "Accurate Gage Work in the Bench Lathe," May, 1910; "Ball Point vs. Anvil Type Thread Micrometers," March, 1910; "An Electric Surface Gage," November, 1909; "The Manufacture of Gages," September, 1909; "Compact Form of Dial Indicator," August, 1909; "Gages for Accurately Sizing Bevel Gear Blanks," March, 1909; "Device for Testing Truth of Cut Gears," January, 1909; "Keyway Gaging in Shafts and Hubs," December, 1908; "Gage for Testing the Planing of a Turret Machine Bed," September, 1908; "Sensitive Indicating Micrometer," September, 1908; "Pack-hardening Gages," June, 1908; "Making Thread Gages," February, 1908; "Micrometer Attachment for Reading Ten-thousandths," February, 1908; "German Bevel Gear Testing Device," February, 1908; "Testing the Lead of Taps and Screws," January, 1908; "Dial Gages for Accurate Measurements," December, 1907; "Radius Micrometer," "Measuring Screw Thread Diameters," and "Wells Bros. Standard and Limit Gages," September, 1907; "Micrometer Heads for Special Gages," September, 1900; "Gages for Bicycle Work," June, 1900.

† Associate Editor of MACHINERY.

In the following article, the fundamental principles governing the setting of limits and tolerances, application of standard and special gages, inspection fixtures, etc., for various classes of work will be dealt with in detail. In addition, systems of handling work in the most up-to-date plants in the country will be described in order to illustrate some of the fundamental principles of interchangeable manufacture. The methods of making some of the principal types of gages, such as plain cylindrical, plug, snap and thread gages, and other inspection tools, taking up machining, hardening, lapping, etc., will also be described.

Development of Interchangeable Manufacture

The original idea of making parts interchangeable is credited to Eli Whitney, a manufacturer of Whitneyville, Conn., a small town just outside New Haven. Mr. Whitney first applied this principle to the production of firearms for the United States government, with the object of being able to replace broken parts of firearms with new ones when in the field. In 1798 Mr. Whitney was given a contract for firearms which were produced on the interchangeable basis. The lock of these firearms was made by employing hardened templets to which the parts were accurately filed. About the same time Simeon North adopted the principle of interchangeable manufacture in the production of army pistols, and from the year 1800 on great strides were made in this direction.

The first complete system of interchangeable manufacture is credited to Elisha K. Root, a New England mechanic, who made a complete system of jigs, fixtures, tools and gages for use in the Colt Armory at Springfield. It has been stated that interchangeable parts were made in France as early as 1717, but that the system was not a success. In 1785, however, a mechanic by the name of Le Blanc made rifles on this basis. The method was not generally adopted, however. In the plant of Sharp, Roberts & Co., Manchester, England, an interchangeable system was adopted in 1825, in which templets and gages were used extensively. The greatest advances in the application of this method of production, however, have been made in the United States, and as has been previously mentioned, the chief advantage gained has been in the gradual reduction of production costs. A reduction has been effected in some cases in spite of the increase in the cost of materials and labor, as has been clearly demonstrated in the Ford Motor Co.'s plant in Detroit.

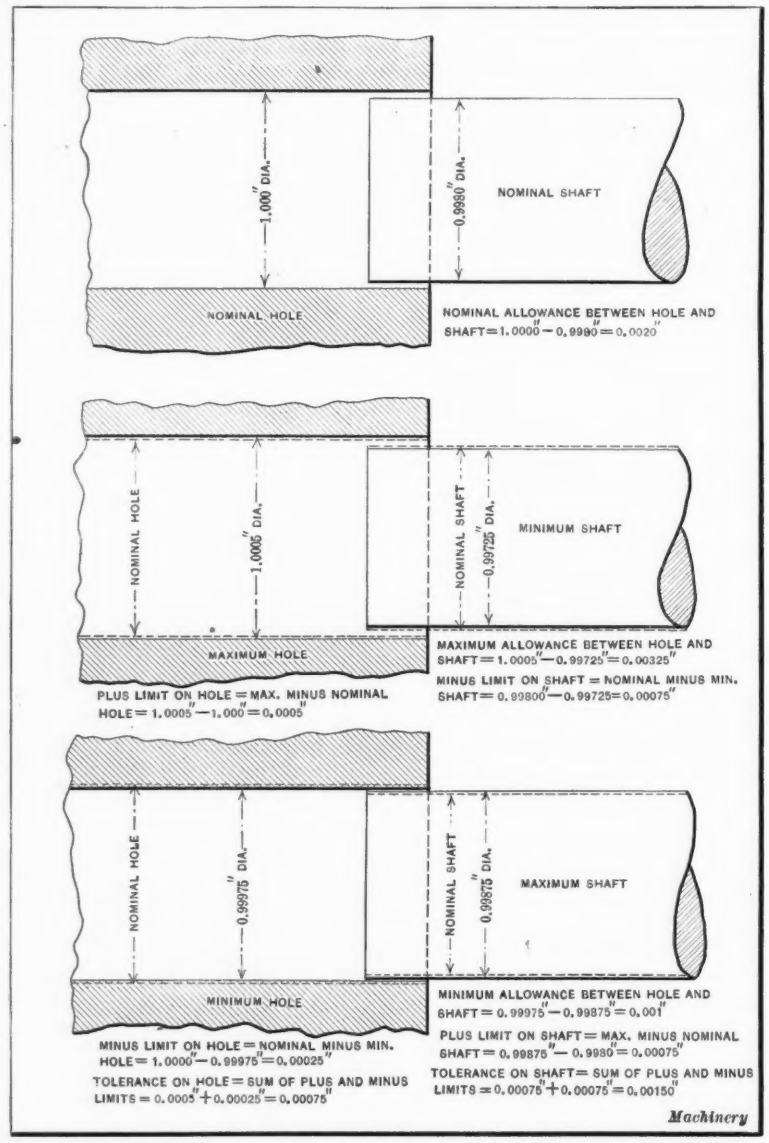

1.000" DIA.
0.9990" DIA.
NOMINAL SHAFT
NOMINAL HOLE
NOMINAL ALLOWANCE BETWEEN HOLE AND SHAFT = 1.0000" − 0.9990" = 0.0020"
NOMINAL HOLE
1.0005" DIA.
NOMINAL SHAFT
0.99725" DIA.
MINIMUM SHAFT
MAXIMUM HOLE
MAXIMUM ALLOWANCE BETWEEN HOLE AND SHAFT = 1.0005" − 0.99725" = 0.00325"
MINUS LIMIT ON SHAFT = NOMINAL MINUS MIN. SHAFT = 0.99800" − 0.99725" = 0.00075"
PLUS LIMIT ON HOLE = MAX. MINUS NOMINAL HOLE = 1.0005" − 1.000" = 0.0005"
NOMINAL HOLE
0.99975" DIA.
NOMINAL SHAFT
0.99875" DIA.
MAXIMUM SHAFT
MINIMUM HOLE
MINIMUM ALLOWANCE BETWEEN HOLE AND SHAFT = 0.99975" − 0.99875" = 0.001"
MINUS LIMIT ON HOLE = NOMINAL MINUS MIN. HOLE = 1.0000" − 0.99975" = 0.00025"
PLUS LIMIT ON SHAFT = MAX. MINUS NOMINAL SHAFT = 0.99875" − 0.9980" = 0.00075"
TOLERANCE ON HOLE = SUM OF PLUS AND MINUS LIMITS = 0.0005" + 0.00025" = 0.00075"
TOLERANCE ON SHAFT = SUM OF PLUS AND MINUS LIMITS = 0.00075" + 0.00075" = 0.00150"
Machinery

Fig. 1. Diagram illustrating Difference between the Terms Allowance, Tolerance and Limit

The Limit System

The limit system which forms the basis of interchangeable manufacture is applied in a variety of ways in various manufacturing plants. In some cases the limit system, as generally understood, is not applied in its entirety. For instance, parts which must go together are made with certain allowances, but no tolerances are given to take care of unavoidable errors in the manufacture of parts. This cannot be called a limit system, because no limits are allowed. Consequently, a great deal more time and money is spent in making the parts than would be the case if the complete system were adopted. In cases where the limit system is not adopted, the parts are made to direct measurement, using standard measuring tools, and unless great care is taken and experienced workmen employed, considerable fitting and assembling is necessary. With a complete system of gaging and inspection, this fitting and assembling is practically, if not entirely done away with, and manufacturing costs are thereby greatly reduced. The advantages of the limit system are not always thoroughly appreciated, and in the following an endeavor will be made to explain some of the chief reasons why this system should be adopted where it is desired to produce parts cheaply as well as interchangeably.

Advantages of the Limit System

The adoption of a limit system and the practice of working to limit gages has many advantages. In the first place, it makes an interchangeable product possible and eliminates the necessity of depending on the judgment of the workman; and probably what is of still more importance, it reduces the amount of spoiled work to a minimum. The initial cost required to install the system in some cases is heavy, but when it is considered that a properly worked out limit system greatly reduces inspection and manufacturing costs, it will be seen that the advantages to be gained will much more than offset the cost involved.

In adopting a limit system for ordinary work, it is necessary to take either the hole or the shaft as a standard. When holes are finished by grinding, it makes little difference which is decided upon. When the hole in the work is finished by reaming or other set tools, and can be duplicated in size with reasonable commercial accuracy, it is advisable to adopt the hole as a basis. There are, of course, exceptions to all rules, and in some cases manufacturers using considerable cold-rolled steel shafting find that it is preferable to use the shaft as a basis instead of the hole. As a general rule, however, the hole basis should be adopted.

Difference Between Allowance, Tolerance and Limit

The terms "allowance," "tolerance" and "limit" are frequently used interchangeably, although as a matter of fact they represent different quantities.

Allowance is the difference between the diameter of the shaft and the hole to allow for various classes of fits, such as drive, push, running, force, etc.

TABLE I. TOLERANCES FOR STANDARD HOLES (NEWALL ENGINEERING CO.)

Nominal Diameters, Inches	0—½	½—1	1 1/16—2	2 1/16—3	3 1/16—4	4 1/16—5	5 1/16—6	6 1/16—7	7 1/16—8	8 1/16—9	9 1/16—10	10 1/16—11	11 1/16—12
Class A													
Max. Limit	+0.00025	+0.00050	+0.00075	+0.00100	+0.00100	+0.00100	+0.00150	+0.00150	+0.00175	+0.00175	+0.00175	+0.00200	+0.00200
Min. Limit	—0.00025	—0.00025	—0.00025	—0.00050	—0.00050	—0.00050	—0.00050	—0.00075	—0.00075	—0.00100	—0.00100	—0.00100	—0.00100
Tolerance	0.00050	0.00075	0.00100	0.00150	0.00150	0.00150	0.00200	0.00225	0.00250	0.00275	0.00275	0.00300	0.00300
Class B													
Max. Limit	+0.00050	+0.00075	+0.00100	+0.00125	+0.00150	+0.00175	+0.00200	+0.00225	+0.00225	+0.00250	+0.00250	+0.00275	+0.00275
Min. Limit	—0.00050	—0.00050	—0.00050	—0.00075	—0.00075	—0.00075	—0.00100	—0.00100	—0.00125	—0.00125	—0.00125	—0.00125	—0.00150
Tolerance	0.00100	0.00125	0.00150	0.00200	0.00225	0.00250	0.00300	0.00325	0.00350	0.00375	0.00375	0.00400	0.00425

Machinery

Tolerance is the difference between the maximum and minimum diameters of either the shaft or the hole necessary to tolerate unavoidable imperfections in workmanship.

Limit is the amount set above or below the nominal diameters of the shaft or the hole in order to limit the amount of error that can be tolerated.

For example, suppose it is necessary to make a shaft with a good running fit in a bushing, as illustrated in an exaggerated form by the three detailed views in Fig. 1. The difference between the nominal diameters of the shaft and hole is 0.002 inch, which is known as the allowance. The limits on the diameters of the hole and shaft, respectively, are — 0.00025 inch, + 0.0005 inch, and ± 0.00075 inch, so that the tolerance on the hole is 0.00075 inch, and on the shaft, 0.0015 inch. For nominal hole of 1 inch and shaft of 0.998 inch, this gives a maximum hole of 1.0005 inch and a minimum shaft of 0.99725 inch, a difference of 0.00325 inch; and a minimum hole of 0.99975 inch and a maximum shaft of 0.99875 inch, a difference of 0.001 inch. From this it will be seen that the "set" allowance between the shaft and hole is what is desired, but seldom obtained.

Setting Manufacturing Limits on Interchangeable Parts

The setting of limits on work which must be made interchangeable is of vital importance to the present-day manufacturer. It is a subject which does not receive the consideration that it deserves. Many manufacturers set the limits much closer than is absolutely necessary to obtain interchangeability. When a part does not need to be made closer than to ± 0.003 inch, this limit should be tolerated. Where greater accuracy is necessary the limits, of course, should be closer. In doing this, no unnecessary time is spent in making parts to closer limits than the conditions actually demand.

TABLE II. TOLERANCES FOR RUNNING FITS (NEWALL ENGINEERING CO.)

Nominal Diameters, Inches	0—½	½—1	1 1/16—2	2 1/16—3	3 1/16—4	4 1/16—5	5 1/16—6	6 1/16—7	7 1/16—8	8 1/16—9	9 1/16—10	10 1/16—11	11 1/16—12
Class R													
Max. Limit	—0.00200	—0.00275	—0.00350	—0.00425	—0.00500	—0.00575	—0.00650	—0.00675	—0.00700	—0.00750	—0.00800	—0.00825	—0.00850
Min. Limit	—0.00100	—0.00125	—0.00175	—0.00200	—0.00250	—0.00300	—0.00350	—0.00350	—0.00350	—0.00375	—0.00400	—0.00400	—0.00425
Tolerance	0.00100	0.00150	0.00175	0.00225	0.00250	0.00275	0.00300	0.00325	0.00350	0.00375	0.00400	0.00425	0.00425
Class S													
Max. Limit	—0.00125	—0.00200	—0.00250	—0.00300	—0.00350	—0.00400	—0.00450	—0.00475	—0.00500	—0.00550	—0.00575	—0.00600	—0.00625
Min. Limit	—0.00075	—0.00100	—0.00125	—0.00150	—0.00200	—0.00225	—0.00250	—0.00275	—0.00275	—0.00300	—0.00325	—0.00325	—0.00350
Tolerance	0.00050	0.00100	0.00125	0.00150	0.00150	0.00175	0.00200	0.00200	0.00225	0.00250	0.00250	0.00275	0.00275
Class T													
Max. Limit	—0.00075	—0.00125	—0.00150	—0.00200	—0.00225	—0.00250	—0.00275	—0.00275	—0.00300	—0.00300	—0.00325	—0.00350	—0.00350
Min. Limit	—0.00050	—0.00075	—0.00075	—0.00100	—0.00100	—0.00125	—0.00125	—0.00125	—0.00150	—0.00150	—0.00150	—0.00175	—0.00175
Tolerance	0.00025	0.00050	0.00075	0.00100	0.00125	0.00125	0.00150	0.00150	0.00150	0.00150	0.00175	0.00175	0.00175

Machinery

For instance, many manufacturers specify the length of a shaft in fractions of an inch and do not give any limits, with the result that the toolmaker or mechanic endeavors to bring the parts exactly to the size mentioned. This is a short-sighted policy, especially where 1/64 inch more or less than the size given on the drawings would make no practical difference in the efficiency of the machine. Take also, for instance, gages, jigs, fixtures or other special tools used in the production of interchangeable parts. It is the practice of some concerns not to give any manufacturing limits on these tools, specify-

TABLE III. TOLERANCES FOR PUSH, DRIVING AND FORCE FITS (NEWALL ENGINEERING CO.)

Nominal Diameters, Inches	0—½	½—1	1 1/16—2	2 1/16—3	3 1/16—4	4 1/16—5	5 1/16—6	6 1/16—7	7 1/16—8	8 1/16—9	9 1/16—10	10 1/16—11	11 1/16—12
Push Fits—Class P													
Max. Limit	—0.00075	—0.00075	—0.00075	—0.0010	—0.0010	—0.0010	—0.0010	—0.00125	—0.00150	—0.00150	—0.00200	—0.00200	—0.00200
Min. Limit	—0.00025	—0.00025	—0.00025	—0.0005	—0.0005	—0.0005	—0.0005	—0.00050	—0.00050	—0.00050	—0.00075	—0.00075	—0.00075
Tolerance	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00075	0.00100	0.00100	0.00125	0.00125	0.00125
Driving Fits—Class D													
Max. Limit	+0.00050	+0.00100	+0.00150	+0.00250	+0.00300	+0.00350	+0.00400	+0.00450	+0.00500	+0.00550	+0.00600	+0.00650	+0.00700
Min. Limit	+0.00025	+0.00075	+0.00100	+0.00150	+0.00200	+0.00250	+0.00300	+0.00300	+0.00350	+0.00400	+0.00450	+0.00450	+0.00500
Tolerance	0.00025	0.00025	0.00050	0.00100	0.00100	0.00100	0.00100	0.00150	0.00150	0.00150	0.00150	0.00200	0.00200
Force Fits—Class F													
Max. Limit	+0.00100	+0.00200	+0.00400	+0.00600	+0.00800	+0.01000	+0.01200	+0.01400	+0.01600	+0.01800	+0.02000	+0.02200	+0.02400
Min. Limit	+0.00050	+0.00150	+0.00300	+0.00450	+0.00600	+0.00800	+0.01000	+0.01200	+0.01400	+0.01600	+0.01800	+0.02000	+0.02200
Tolerance	0.00050	0.00050	0.00100	0.00150	0.00200	0.00200	0.00200	0.00200	0.00200	0.00200	0.00200	0.00200	0.00200

Machinery

ing that all dimensions should be exact. Thus much unnecessary time is consumed in making the tools, which even under the most favorable conditions cannot be made exactly alike. Some go so far as to state that a plug or ring gage should be made exact and have no limit of error at all. Those making such a statement only hold themselves up to ridicule, as it is practically impossible to make two parts exact; a slight change in temperature will easily move a plug gage 0.000025 inch. Several large manufacturing concerns have set limits on work produced in the tool-room with satisfactory results, but, of course, an experienced designer or draftsman is required to set limits which are reasonable and consistent with the requirements of the tool being made.

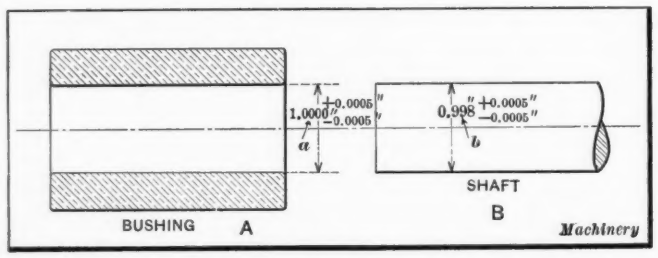


Fig. 2. Diagram illustrating Method of setting Limits for obtaining Running Fit

Various Methods of Establishing a System of Limits

Many methods have been evolved for establishing a system of limits, and careful study of this subject has revealed the fact that practically no two manufacturers use the same system of setting limits or give the same permissible amount of error in manufacturing. In some cases the limits are stated directly on the drawing; in others the size of the part is given in fractions or decimals of an inch, the method of presenting the dimension being an indication of the permissible limit allowed. In some cases it is stated on the drawing that where dimensions are given in fractions of an inch, a tolerance of 1/64 inch above or below the dimension given is permissible. If the dimensions are given to two decimal places, the limit can be ± 0.005 inch; to three decimal places, ± 0.0015 inch; to four decimal places, ± 0.0005 inch; and to five decimal places, ± 0.0002 inch.

It is a difficult matter to decide upon the permissible error between parts, as this depends entirely on the character of the work and the conditions under which the parts are to operate. For instance, there are different classes of fits desired, such as push, drive, running, slide, force, etc. The variation or allowance between the female and male members depends on several factors, among which might be mentioned: diameter and length of hole, material, speed, load carried, etc. Consequently, no set rules can be established for this work. Several concerns, however, have established limits derived from practice, which with proper judgment can be used to good advantage. One system which has been adopted by the Newall Engineering Co. of England is given in Tables I to III, inclusive.

Simple Method of Establishing Manufacturing Limits

There are several questions to be decided in setting limits on parts which must go together. Ignoring, for the present, the method used in making the parts, which, of course, is an important matter, the two points which should be settled are, first, permissible maximum and minimum allowances between the shaft and hole; and second, manufacturing limits or tolerance on the hole. When these two points have been satisfactorily decided upon, it is a simple matter to establish limits on both the hole and shaft.

As an illustration, assume that it is necessary to obtain a running fit between the shaft and bushing shown in Fig. 2, and that the hole in the bushing is to be produced by reaming. The first question to decide is the maximum and minimum allowances. In this particular case we will say that the maximum allowance is 0.003 inch and the minimum 0.001 inch. The next question to decide is the permissible tolerance on the hole. As a standard reamer cuts slightly over size, we will make the hole as shown in Fig. 2, 1.000 inch ± 0.0005 inch. This gives a tolerance on the hole of 0.001 inch. Now, to set the limits for the shaft, we subtract from the nominal diameter of the hole, or 1.000 inch, the mean allowance, or 0.002 inch. This gives us a nominal shaft diameter of 0.998 inch. The limits can now be set on the shaft, in a similar manner to the hole, thus giving a manufacturing tolerance of 0.001 inch. By this method of establishing limits, no checking back is necessary and the allowances previously set, of course, are obtained in the product.

Checking back, however, in this case to prove that our assumption is correct, we find that the largest hole is 1.0005 inch and the smallest shaft 0.9975 inch, which gives us an allowance between these two sizes of 0.003 inch — the maximum permissible allowance. The minimum sized hole is 0.9995 inch and the maximum shaft 0.9985 inch, which gives us a difference of 0.001 inch, or the minimum allowance between the hole and the shaft. The manufacturing limits set on the work, of course, do not affect the original established allowances between the parts, and in this way there is no danger of having the minimum hole the same size as the maximum shaft, which is sometimes the case when the manufacturing limits are set in a haphazard manner.

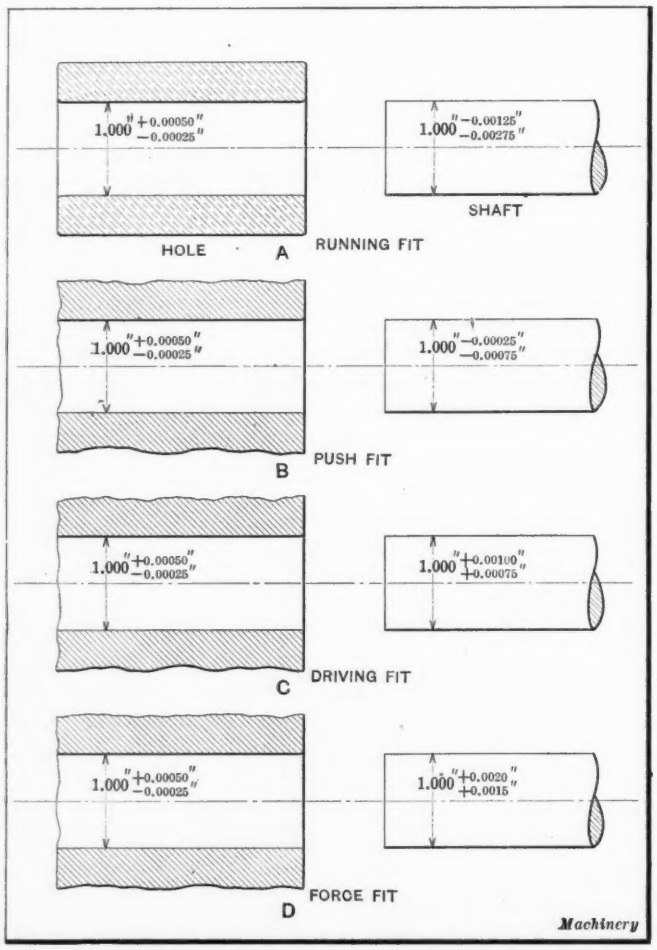


Fig. 3. Diagram illustrating Method of setting Limits for Various Classes of Fits

Allowances for Various Classes of Fits

In order to provide for various classes of fits, such as push, drive, force, etc., it is necessary to make certain allowances between the diameters of the hole and shaft. As the hole basis is taken to be the standard in most cases, the size of the hole, therefore, is the first question to decide. Table I gives two lists of tolerances for standard holes varying from 0 to 12 inches in diameter and known as classes A and B. Class A is preferred by some manufacturers as manufacturing limits, and class B as inspection limits. In using the hole as a basis or standard, the shaft is made to suit the hole, depending on the type of fit desired. In order to make the following description clear, it may be advisable to describe what the different classes of fits mean. The classes of fits used in ordinary practice are as follows: running, push, drive and force fits.

Running Fit.—Running fits are divided into three classes

or grades known as classes R, S, and T. Class R is used principally for engine and other work where easy fits are wanted, and also for shafts running in several bearings or a single bearing of unusual length. Class S is for high speeds and good average machine work, and also for shafts running in a single bearing of ordinary length. Class T is for fine tool work, sliding shafts and similar work. The limits given in Table II for running fits can also be employed for other than revolving fits where it may be advisable or necessary to limit the manufacturing error on the parts.

Push Fit.—Push fits, known as class P, the limits for which are given in Table III, are for shafts that are forced into a hole by hand and that would be free to rotate without seizing, but not free enough to rotate under anything but a very slow speed. Usually there is sufficient friction between the hole and the shaft to prevent free rotation. Push fits are usually employed where one member is fitted into another and then held in place with a key or pin.

Drive Fit.—Drive fits, known as class D, will produce shafts that need to be driven into holes either with a heavy hammer or with a light arbor press, and are distinguished from push fits in that shafts made to the limits given in Table III can be easily driven into a hole, but will not be able to rotate freely.

Force Fit.—Force fits, known as class F, are for shafts which require either hydraulic pressure to force them into the holes, or for those in which the female member must be expanded by heating so as to shrink it onto the shaft.

Establishing Allowances and Tolerances for Various Classes of Fits

The method used in establishing allowances and tolerances for a running fit has been previously described in a general way. We will now take a concrete example, illustrated at *A* in Fig. 3, using the limits of tolerance given in Tables I and II. Assuming the nominal hole to be 1.000 inch diameter and using class A limits, we obtain a hole $1.000\ ^{+\ 0.00050}_{-\ 0.00025}$ inch. This gives a manufacturing tolerance of 0.00075 inch. The diameter of the shaft is then made smaller than the hole by making use of the limits given in Table II. Reference to this table will show that the shaft is made $^{-\ 0.00125}_{-\ 0.00275}$ inch less than the nominal hole. This gives a hole and shaft of the following dimensions: maximum hole 1.0005 inch, minimum, 0.99975 inch; maximum shaft 0.99875 inch, minimum, 0.99725 inch. The difference or allowance between the minimum hole and maximum shaft is 0.001 inch, and the difference between the maximum hole and minimum shaft, 0.00325 inch. The tolerance between the maximum and minimum hole is 0.00075 inch, and the tolerance between the maximum and minimum shaft, 0.0015 inch.

In making a shaft which must be a push fit in a hole, the amount of tolerance permissible on the shaft is considerably less than for an ordinary running fit. As indicated at *B* in Fig. 3, the tolerance on the shaft is made with a minimum limit of —0.00025 inch and a maximum limit of —0.00075 inch. This allows no theoretical difference between the maximum shaft and minimum hole; in other words, the smallest hole and the largest shaft are of the same dimensions, or 0.99975 inch diameter. The difference between the largest hole and smallest shaft is 0.00125 inch. In this case the ideal allowance desired between the shaft and the hole is 0.00075 inch, which is the difference between the mean dimensions of the hole and the shaft, respectively.

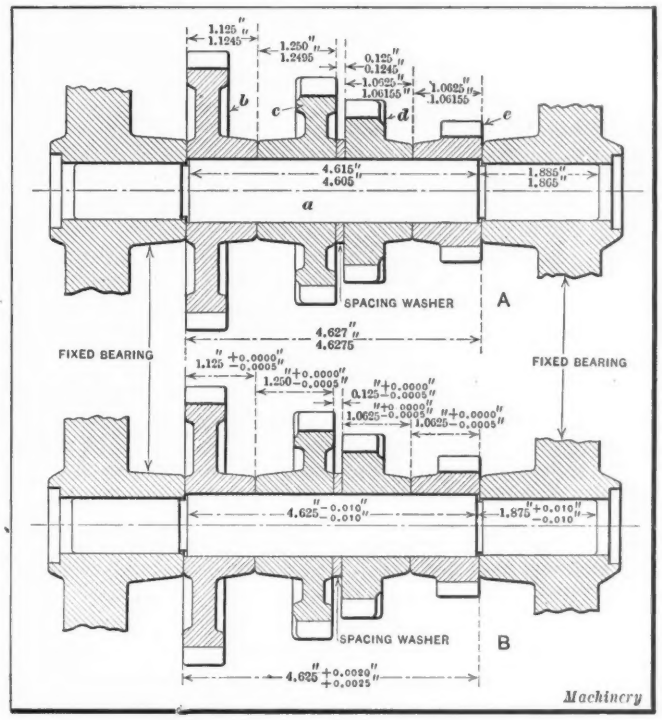


Fig. 4. Diagram illustrating Two Methods of dimensioning Drawings

In making a drive fit, it is necessary, of course, to have the shaft slightly larger than the hole, so that the required amount of grip on the shaft will be obtained. As before, the hole is made with plus and minus limits, as shown at *C* in Fig. 3. The shaft is made larger than the hole and has a maximum limit of + 0.001 inch and a minimum limit of + 0.00075 inch. This produces a condition in which the largest hole is 0.0005 inch smaller than the largest shaft, and the smallest hole is 0.00125 inch smaller than the largest shaft. This insures in all cases that the parts will go together with a suitable driving pressure.

The conditions for a force fit are similar to those for a driving fit, with the exception that a greater allowance is made between the diameters of the shaft and hole, respectively, in order to obtain a tighter union between the parts. As shown at *D* in Fig. 3, the shaft is made $1.000\ ^{+\ 0.0020}_{+\ 0.0015}$ inch. This gives an allowance between the smallest hole and largest shaft of 0.00225 inch, and a difference between the largest hole and smallest shaft of 0.001 inch.

Various Methods of Presenting Manufacturing Limits on Drawings

In setting manufacturing limits on interchangeable parts, various methods are adopted for expressing the limits of error to be tolerated. Expressions such as plus and minus, low and high, maximum and minimum are commonly used. There are two important points to be observed when setting manufacturing limits on parts. The first is to so set these limits that the operator can clearly understand the drawing, and second, to express them in such a way that the draftsman who checks up the drawing can conveniently tell whether the parts have been properly dimensioned or not.

A practical example which will serve to illustrate this point is shown in Fig. 4. Here a set of gears for the lower part of an automobile transmission is shown in section, and to simplify the problem the shaft *a* is shown supported in two fixed bearings. The four gears *b*, *c*, *d* and *e* are keyed to this shaft and separated by a spacing washer. The washer provides for inaccuracy of parts, and while this practice is not recommended, the example is so simple that it has been used in place of a more complicated one.

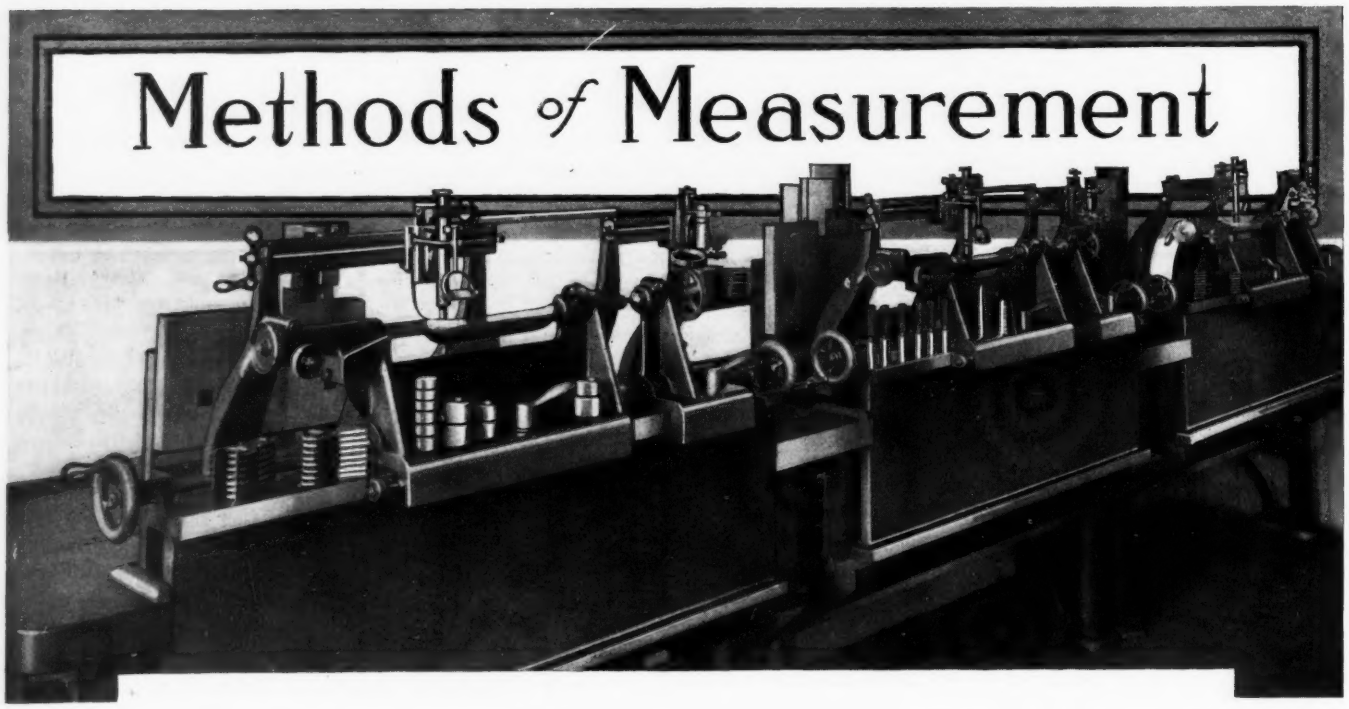
Reference to Fig. 4 will show that two methods are used for dimensioning the parts. As shown at *A*, the minimum and maximum sizes or widths of the gear shoulders are given and the minimum and maximum distances between the bearings. In presenting the dimensions in this manner it makes it extremely difficult for the checker to determine whether any mistakes have been made in dimensioning or not. It requires a careful addition of the different dimensions and then checking to see if the required allowance between all the gear shoulders and bearing faces has been provided. Assuming that the minimum allowance between all the gears and bearing faces is 0.002 inch and the maximum allowance 0.005 inch, the method of setting the limits on the drawing would be as follows:

Inspection will show that there are five parts, so that the total manufacturing limits on the gears should not exceed 0.0025 inch, as a limit also has to be provided for the distance between the bearing faces. In other words, there are six dimensions to take into consideration, allowing a limit of 0.0005 inch on each; this totals 0.003 inch, or the difference between

the maximum and minimum allowances. As soon as this question is settled, it is a simple matter to place the limits on the different parts. For the gears, no plus limits are tolerated and a minus limit on each part of 0.0005 inch is provided. The dimension given on the drawing to represent the distance between the bearing faces is a nominal dimension and is equal to the sum of the gear shoulders and washer. But as a minimum allowance of 0.002 inch is necessary, the minimum distance between the bearing faces would be the nominal dimension, or 4.625 inches + 0.002 inch, and the maximum, 4.625 inches + 0.0025 inch. To show that this is correct, we add the nominal dimensions on the gears and washer, which equals 4.625 inches, as the maximum. The minimum is 4.625 inches — 0.0025 inch, or 4.6225 inches. The maximum distance between the bearing faces is 4.6275 inches, and the minimum, 4.6270 inches. This gives us an allowance between the minimum gear shoulders and maximum bearings of 0.005 inch, and an allowance between the maximum gear shoulders and minimum bearing faces of 0.002 inch.

Inspection of the two methods of presenting these dimensions at *A* and *B* will show that the one illustrated at *B* is by far the simpler from the standpoint of checking up the drawing. It will be seen that at *B* no plus limit is allowed for the gears and no minus limit for the space between the bearings. Hence, the checker can immediately see that these gears are to be made with a running fit between the bearing faces. In the case shown at *A*, this is more difficult to ascertain without actually checking up the different dimensions and ascertaining the allowance between the gear shoulders and bearing surfaces.

Methods of Measurement



IN measuring work, many different appliances are used, the kind of tool depending on the accuracy required. For instance, in ordinary machine work, the bow caliper and scale are used to a large extent for making diameter and length measurements. When the work calls for a greater refinement, the micrometer caliper, vernier caliper, micrometer depth gage, etc., are applied. When still greater accuracy is demanded, standard measuring machines as well as scientific measuring appliances are adopted. For angular measurements, squares, bevel protractors and templets are used. The average mechanic is familiar with the use of the bow caliper, micrometer caliper, vernier, bevel protractor, etc., so that an extended description of these tools is not necessary here. This subject has also been exhaustively dealt with in the pages of MACHINERY. Many mechanics, however, are not familiar with the different types of standard measuring machines used in gage manufacture and the originating of the standards by means of which various tools are checked.

Standard Unit of Length

The international meter is the fundamental metric unit of length in the United States. The original standard is retained by the International Bureau of Weights and Measures, near Paris, France. Several copies of this primary standard were made in 1889 for the United States and other governments under the direction of the International Committee representing the various countries which support the bureau. The Bureau of Standards, Washington, D. C., has two copies of the original meter; one—No. 27—is kept sealed in a metal case in a fireproof vault, and the other—No. 21—is used occasionally to verify the working standards. The legal equivalent of the meter for commercial purposes was fixed by law in 1866 as 39.370788 inches. The United States Bureau of Standards was authorized by executive order, in 1893, to derive the yard from the meter by the use of this relation. Metric length measures tested by this bureau are standardized at 20 degrees C., and standards in the customary units of yards, feet and inches are made to be correct at 62 degrees F.

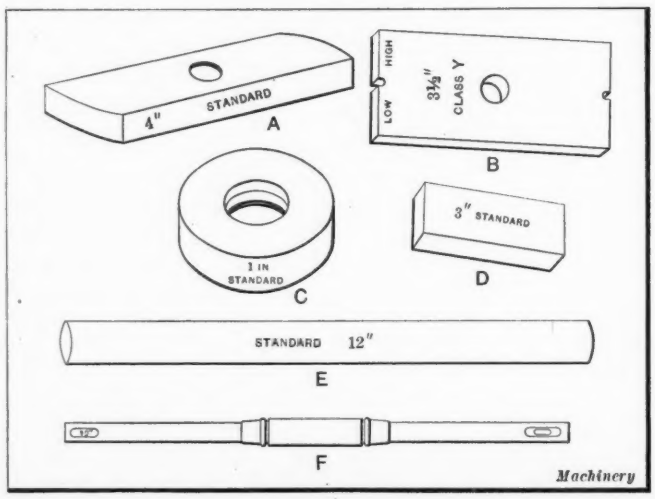


Fig. 5. Standard Reference Blocks, Disks and End Measuring Rods

Reference Standards

In order to check up various measuring instruments, micrometer calipers, standard and special gages, etc., different types of reference rods and blocks have been devised. These are very carefully seasoned and lapped, and are usually supplied in sets vary-

ing from blocks of the thickness of feelers to rods several feet in length. Fig. 5 shows several types of reference blocks, disks and rods. The block shown at *A* is made from steel, hardened and ground, with cylindrical ends, and is used for setting micrometers and other adjustable measuring tools. *B* shows another type of block which is particularly adapted for setting the adjustable points of limit gages. A disk type of standard which is used principally for setting micrometer calipers is shown at *C*, while a standard block used both for setting gages and for general tool-room purposes is shown at *D*. *E* is a standard end-measuring rod, which is made with rounded ends having a section of a true sphere with a diameter equal to that for which the rod is made to measure. These rods are made ⅜ inch diameter for lengths from 3 to 6 inches, and ½ inch diameter for lengths from 6 to 16 inches. *F* shows another type of standard reference rod, which is made from round steel rods, hardened, ground and lapped on the ends. To prevent expansion due to handling when in use, the center portion of the rod is fitted with a sleeve of insulating material.

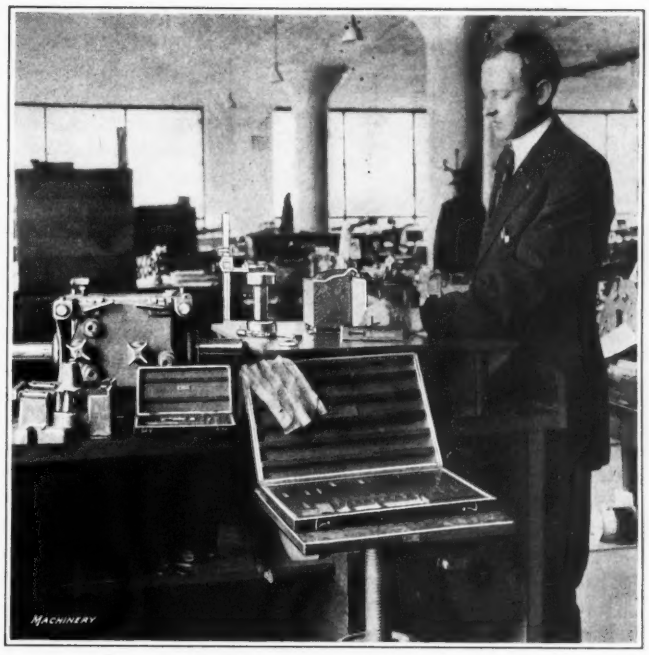


Fig. 6. Johansson Reference Blocks

Johansson Reference Blocks

The Johansson system of reference blocks was originally designed to be used in the tool-room for quickly laying out and checking gages and fixtures. Owing to the extreme accuracy to which these blocks are made, however, they are also used as references, both for manufacturing and inspection purposes. Fig. 6 shows one set of these blocks in use in the inspection department for checking gages and fixtures. The combination consists of a series of rectangular blocks, which are made from "Invar" steel, carefully machined, seasoned, ground and lapped on all sides. The opposite sides of each block are parallel, and the distance between them is equal to the dimension stamped on them within a maximum tolerance of 0.00001 inch. These blocks are supplied in various sets, set No. 1, shown in Fig. 6, comprising eighty-one blocks, divided into four series. The first series contains nine blocks, which vary in thickness from 0.1001 to 0.1009 inch, increasing by 0.0001 inch increments. The second series contains forty-nine blocks, which vary in thickness from 0.101 to 0.149 inch, increasing by 0.001 inch. The third series comprises nineteen blocks, varying in thickness from 0.050 to 0.950 inch, increasing by 0.050 inch increments; and the fourth series consists of four blocks, of 1, 2, 3 and 4 inches. This set gives all the sizes from 0.0500 inch up to 10 inches. When furnished with standard plugs and holder for retaining these blocks, over 100,000 different internal and external gages are obtained. The range can be increased by adding other series of blocks up to 20 inches, and increments in quarter thousandths can be obtained by adding two blocks, 0.10025 and 0.10075 inch.

These blocks are generally used by building them up to obtain the required size, and owing to the almost perfect flatness of the surfaces, they can be wrung together with sufficient pressure so that the total number in the set (eighty-one) can be built up. The contacting surfaces are carefully cleaned with chamois skin, and then the gages are slid over each other with a slight pressure.

To illustrate how these blocks are used in combination to get any desired size, assume that it is necessary to measure 3.3625 inches. This can be made up by using four blocks: 3.000, 0.140, 0.122 and 0.1005 inch. Other combinations can also be used for the size given. These blocks can also be extensively used for setting and checking limit gages. With the set of eighty-one blocks, any limit gage having a tolerance as small as 0.0005 inch, up to about 10 inches, can be checked, and by the addition of the two blocks of 0.10025 and 0.10075 inch, it will be evident that limits as fine as 0.00025 inch can be verified.

Bench Micrometer Caliper

One of the simplest types of measuring instruments, which comprises the principle of the micrometer screw and graduated sleeve, is shown in Fig. 7. This is known as a bench micrometer caliper and is used on the bench for taking fine measurements from 0 to 6 inches. It is provided with two interchangeable measuring heads, the one shown on the instrument being graduated to read to 0.0001 inch directly from the thimble, and the other shown at *A* being provided with a ten-pitch screw and graduated to read to 0.001 inch. The thimbles are 4 inches in diameter, and consequently have coarse graduations, enabling accurate readings to be quickly taken. The adjustable anvil is set by standard reference blocks. The screw on the thimble has a movement of 1 inch.

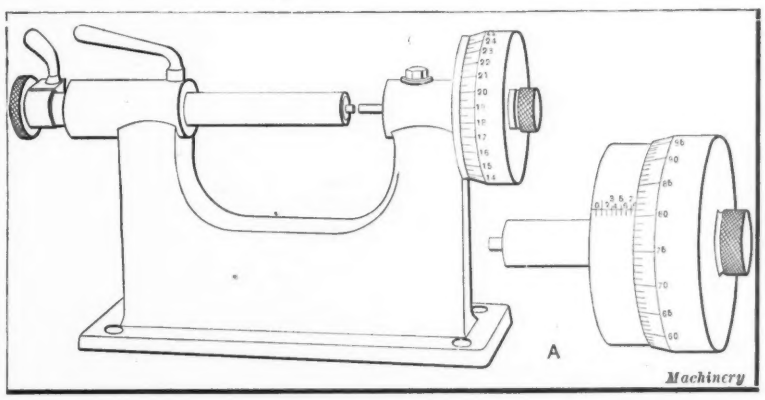


Fig. 7. Bench Type of Measuring Machine

Principle of Standard Measuring Machines

Standard measuring machines generally comprise both a vernier scale and a micrometer screw and wheel. Usually the vernier scale is attached to the bed of the instrument and is used for setting the headstock bracket carrying one anvil; the headstock also carries the graduated wheel operating the spindle through a screw. There are three important points to consider in designing a measuring machine: first, to produce an aecurate screw, vernier and wheel; second, to secure the proper proportions and rigidity of bed; and third, to provide some means of indicating the pressure exerted on work placed between the measuring points.

While all three points are highly important, the third one is probably the most important and the one that should receive the most careful attention. A measuring machine not provided with a pressure indicating device is only of value in the hands of an expert, and it is practically impossible for two men to obtain exactly the same readings. Pressure indicating devices are made in several forms, such as feeler plugs, which drop out from between points when a certain pressure is reached; levels which are inclined at an angle when acted upon by the moving anvil; spring operated plungers,

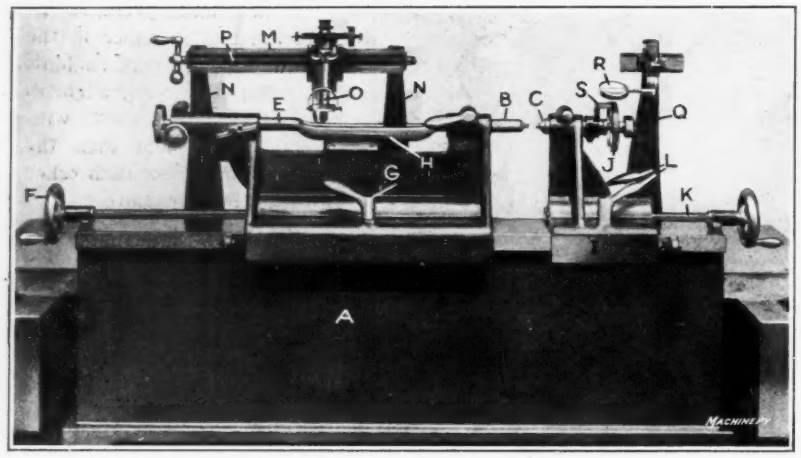


Fig. 8. Brown & Sharpe Measuring Machine

in conjunction with a scale and hair line microscope; and graduated glass tubes up which a colored liquid is forced by the pressure of a diaphragm connected to the movable anvil. These various devices as well as other of the recording and indicating types will be described in connection with several interesting machines in the following.

Brown & Sharpe Measuring Machine

The measuring machine designed and used by the Brown & Sharpe Mfg. Co. for testing the accuracy of standard gages and other tools that must be finished to very accurate dimensions is shown in Fig. 8. This machine belongs to that class of measuring instruments in which the measurement is made by means of a moving scale under a microscope, used in conjunction with a micrometer screw and vernier. The most important feature of this machine is that all measurements are made directly from the scales, and dependence is not placed upon standard test pieces that have been previously measured by other means.

In construction, this measuring instrument consists of a heavy bed *A* made of double I-beam section about 4 feet long and 1½ foot deep. The I-beam section combined with the weight of the bed gives this machine great rigidity to resist any tendency to deflect when the anvils or measuring points *B* and *C* are brought into contact with the piece to be measured. The carriage *D* on the left-hand side of the bed supports bar *E* which carries the graduated scale. This carriage is moved by adjusting screw *F*, and clamped by the handle *G*. Bar *E* is provided with coarse and fine graduations and its central portion, which carries the graduated scale, is cut away, thus placing the scale in a line with the axis of the measuring points. The guide *H* which fits in a slot in the lower surface of the bar holds it rigidly in position.

The carriage *I* on the right-hand end of the machine supports the micrometer adjustment *J*. This carriage is regulated by an adjusting screw *K* and clamped by handles *L*. Measuring points *B* and *C* are integral parts of the cylindrical bar and micrometer screw, respectively. The slide *M*, supported parallel to the bar *E* by the uprights *N*, carries the microscope *O*. Screw *P* is used to adjust the microscope along the slide. Upright *Q* holds the reading microscope *R* that facilitates taking readings with the micrometer vernier.

The scale on the bar *E* is 8 inches long and is attached to a flat surface. It has two lines of graduations, each division being 0.025 inch. One line of graduations, which is easily visible to the naked eye, is used for locating the scale approximately. The other graduations, which are invisible to the naked eye except under favorable light conditions, are used for the exact reading of the scale by means of the microscope *O*. The lines of these graduations are 0.0001 inch wide, being the same width as the hair line of the microscope; thus the two lines can easily be brought to coincide. The machine can be set to measure distances up to 16 inches long.

The micrometer wheel *J* is graduated to read to 0.0001 inch, and the vernier plate *S* used in connection with the wheel, makes it possible to obtain readings as fine as 0.00001 inch. The wear of the micrometer screw amounts to practically nothing, inasmuch as the micrometer readings are only used for short distances and the wheel never moves more than half a turn. The accuracy of this screw is also greatly increased by providing it with a bearing practically equal to its length.

Method of Taking Measurements

To measure an object, slide *D* carrying bar *E* is moved to the right so that the measuring point *B* will touch the micrometer point *C*. The microscope *O* is then set over one line of the scale, generally the zero line, and the slide is moved to the left until the nearest graduation of the required size is reached. This is indicated by bringing the line of the scale under the hair line of the microscope. The slide is then fastened by clamping handle *G*. Readings less than 0.025 inch are indicated by the micrometer screw and dial *J*. The object to be measured is inserted between the measuring points *B* and *C*, and by adjusting the micrometer screw the size can be indicated to 0.00001 inch.

The accuracy of this machine rests fundamentally upon the accurate graduations on the scale and the perfection of the micrometer screw. Among other factors that contribute to the accuracy of the machine are the weight of the bed and the rigidity of the carriages that support the measuring instrument. All bearings and wearing surfaces are scraped accurately to reduce any possible error. The machine is also firmly braced. As an example of the accuracy of this machine, it might be mentioned that a pull of about fifty to seventy-five pounds on the bed directly beneath the measuring points is sufficient to make a plug ¼ inch diameter drop out from between the measuring points. Another test which shows the sensitiveness of the machine is placing the hand on the bed between the slides and holding it there for approximately one minute; the heat of the hand causes the plug to drop from the measuring points. It is estimated that it requires about twenty minutes for the machine to reset itself and overcome the influences exerted by the pull or temperature test.

Pratt & Whitney Standard Measuring Machine

The Pratt & Whitney standard measuring machine shown in Fig. 9 employs what is known as a feeler plug for determining the pressure between the measuring points, thus eliminating the human element. This machine consists of a heavy cast-iron bed provided with ways upon which two heads are mounted. One head *A* is normally fixed to the bed, whereas the other head *B* is adjustable and is located along the bed by means of a powerful microscope *C* and finely divided measuring points *D*, consisting of plugs provided with fine lines that are spaced exactly one inch apart. Each head carries a

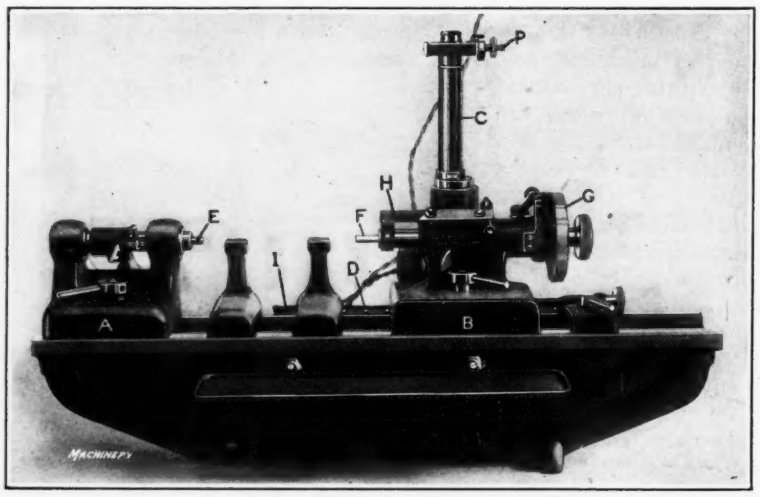


Fig. 9. Pratt & Whitney Measuring Machine

spindle or measuring point *E* and *F*, and the parts to be measured are supported between these spindles upon rests, or held in the hand if very small. Measurements up to one inch are obtained by means of a large graduated index wheel *G*, a scale and pointer at *H* being provided for approximate setting. This is more clearly shown in Fig. 10, where it will be seen that scale *J* has twenty-five graduations representing a movement of the spindle of 1.000 inch, and pointer *K* has a single setting line. For measurements greater than one inch, the sliding head *B* is set by means of a standard bar *I* located at the rear of the machine. This bar carries a series of plugs *D* which are provided with graduations exactly one inch apart and so fine that they are imperceptible to the naked eye. The screw of the sliding head spindle, by means of which the adjustments for fractional parts of an inch are obtained, has twenty-five threads per inch, and the index wheel has 400 graduations. Therefore, each graduation represents 1/400 of 1/25 inch, or 0.0001 inch. These divisions can easily be split up by estimating to at least five points, making possible the reading of accurate measurements to 0.00002 inch with little difficulty.

In order to insure proper contact between the measuring points of the instrument, the machine is provided with an indicating device on the fixed head *A*. This consists, as shown in Fig. 11, of two auxiliary jaws *L* and *M*, between which a small ¼-inch diameter plug *N* is held by the pressure of a light helical spring which operates the sliding spindle to which one of the jaws is attached. The tension of this spring is so adjusted that when the measuring points are not in contact the jaws will hold the plug *N* by friction in a horizontal position, as shown to the left in Fig. 11. When the measuring points are in contact with one another or with the work being measured, the tension on this helical spring is slightly reduced and the plug *N* swings down to a vertical position between the jaws, as shown to the right of the illustration. Should there be an excess pressure between the jaws the plug would drop out. Hence, the contact for all measurements should be just enough to cause plug *N* to swing down to a vertical position and not drop out. It is estimated that the measurable difference between the faces of the measuring spindles when the feeler plug is in the horizontal and vertical positions is 1/250,000 inch.

In checking a measurement, the machine should first be set to the zero position with the measuring points in contact. This is done by adjusting the screw of the linear scale at the top of the head to zero and setting the pointer of the index wheel *G* nearly to zero. Then the head is slid along the bed until the measuring faces are almost in contact. For the last adjustment, screw *O*, Fig. 10, is operated until the feeler plug *N*, Fig. 11, shows a tendency to move to the horizontal position. The head is now clamped firmly in position and the index wheel adjusted until the plug swings to a vertical position. Then the adjustable index pointer is set to zero and the line in the eye piece of the microscope is set so that it exactly coincides with the zero line of the graduated reference bar *I* at the rear of the machine. The adjustment of the line in the eye piece is made by means of the screw *P*. The machine is now set to the zero position, and when adjusting the head for the required measurement, care must be taken not to disturb the eye piece of the microscope. To measure from zero to one inch, the micrometer screw can be used direct, but for a greater dimension the sliding head must be located by means of the microscope so that the line in the microscope is set exactly on the nearest graduation on the plugs on bar *I*. Assuming that it is necessary to take a measurement of 12.2508 inches, slide the movable head *B* along the bed until the microscope is brought directly in line with the 12-inch graduation on bar *I*. The screw is now turned back until the scale and index wheel of the adjustable spindle show a movement of 0.2508 inch. As the pitch of the screw is 1/25 inch, a complete turn of the index wheel equals 0.04 inch. Hence for a movement of 0.2508 inch, the number of turns of the index wheel would be $0.2508 \div 0.040 = 6.27$, or six full turns and 108 divisions. The Pratt & Whitney measuring machines are graduated for English measurements at a standard of 62 degrees F., and in sizes from 12 to 144 inches.

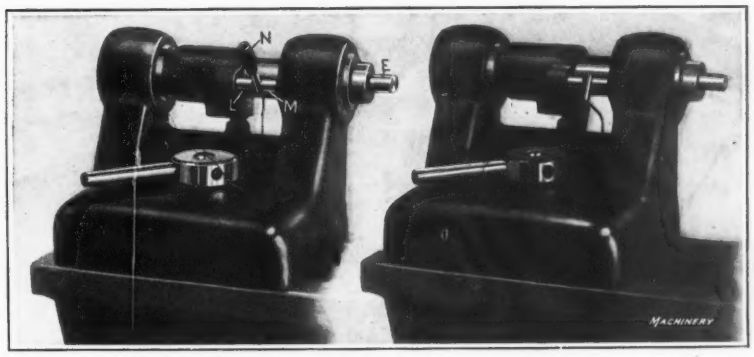


Fig. 11. Close Views of Pratt & Whitney Measuring Machine, showing Position of Feeler Plug before and after taking a Measurement

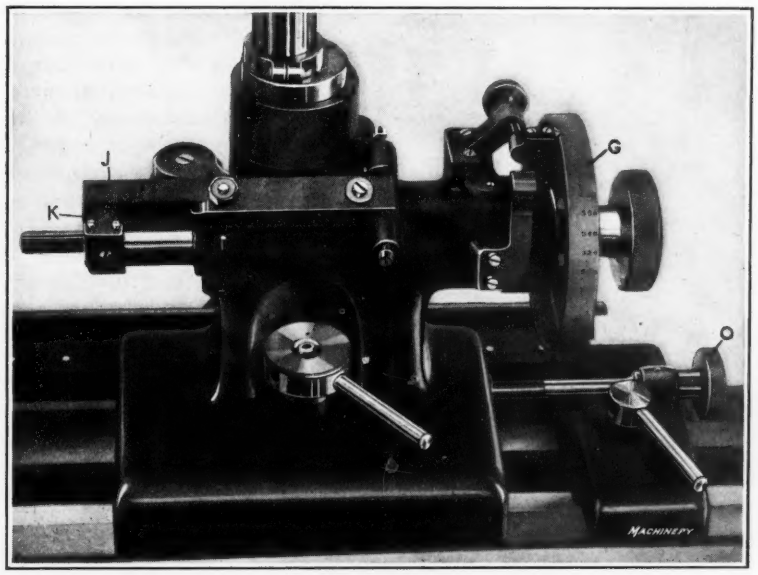


Fig. 10. Close View of Pratt & Whitney Measuring Machine, showing Graduated Wheel and Vernier Scale

Slocomb Standard Measuring Machine

The type of measuring machine used by the J. T. Slocomb Co. is shown in Fig. 12. This machine is of comparatively simple construction, and consists of a bed carrying two heads. The heads are of circular section and slide in a V-groove in the bed, and when set in the required position are clamped by a C-clamp, as shown. This machine is used principally for duplicating measurements by using master end measuring rods for setting. The screw has a 40-pitch thread and the dial is 5 inches diameter and reads to 0.0001 inch.

The most interesting part of this measuring machine is the device for indicating the pressure exerted between the measuring points. It is a well-known fact that when taking measurements to 0.0001 inch with an ordinary micrometer it is difficult to know just what pressure is being applied on the work; and two inspectors seldom obtain the same reading. This pressure indicating device, which is shown in detail in Fig. 13, eliminates the human factor in taking accurate measurements. In Fig. 13, *A* represents a section through the tailstock to which the device is attached, and *B* is the plunger anvil which is retained in bushings. This anvil is made a nice sliding fit in the bushings, and is kept against the front bushing by means of the spring *C*. The movement of the anvil is limited by means of the pin *F* driven into the collar and working in an elongated slot in the tailstock *A*. The rear end of the anvil *B* is pointed to an angle of 60 degrees and rests against a flat portion on pin *E* which is retained in the lower end of lever *G*. Pin *E* is fulcrumed on two cone-pointed screws, as shown in the view to the left, and its axis is located 1/16 inch below the point of the plunger. The ratio between the short and long arms of the lever is 0.062

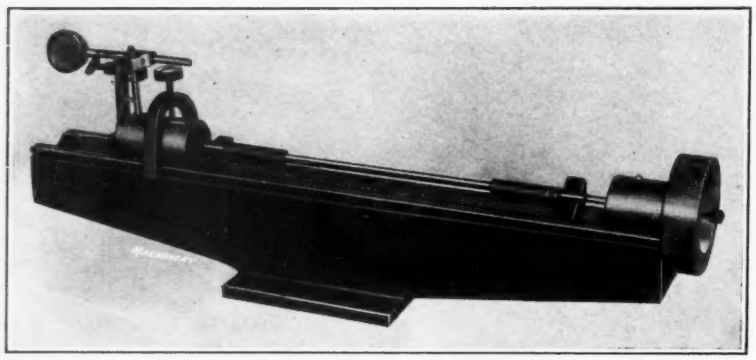


Fig. 12. Slocomb Standard Measuring Machine

to 4 inches, so that when anvil *B* moves 0.0001 inch, the top part of lever *G* moves about 0.0064 inch. The top part of lever *G* bears against the plunger of the dial indicator *H*, and the indicator hand moves about ⅜ inch when the plunger or anvil *B* is moved 0.0001 inch. An interesting test made in connection with this instrument showed that the heat from three fingers of the hand applied for a few seconds to a 4-inch end measuring rod, 5/16 inch in diameter, was sufficient to move the hand of the dial indicator ¼ inch. In testing two pieces with this instrument, the needle will stand at zero when they are of the same length. If the needle moves from zero, it indicates that there is a variation between the length of the two pieces.

Swiss Standard Measuring Machine

A measuring machine which differs somewhat in principle from those previously described is shown in Figs. 14 and 15. This machine is built by the Societé Genevoisé, Geneva, Switzerland, and comprises two hair line microscopes *A* and *B*. Microscope *A* is used for setting movable head *C* when taking measurements of over twenty-five millimeters. This microscope is provided with cross-hairs which are brought in line with the graduated marks on a scale located at the rear of the instrument. This scale is 51 centimeters long and is graduated in millimeters. Microscope *B* is used for determining the position of spring plunger *D*, which governs the pressure exerted on the work. Head *E* is fastened rigidly to the base and carries the stationary anvil *F*, which can be adjusted in case of wear. Spindle *D* is held in a sleeve *H*, the movement of which is controlled by a screw of ½ millimeter pitch and which is attached to the graduated wheel *I*. Located behind spindle *D* is a light spring capable of exerting a pressure on the work of one pound per square inch.

In setting the machine for measurements over twenty-five millimeters, head *C* is slid along the bed until both anvils contact with sufficient pressure so that the line on the sliding spindle is exactly central between the two cross-hairs in microscope *B*, the graduated wheel *I* at the same time being set at zero. The head is now moved back to approximately the distance required, using the coarsely graduated brass scale at the rear, and is clamped by handle *K*, Fig. 14. Screw *L* is then adjusted until the cross-hairs in the telescope *A* exactly coincide with the required graduation on the scale at the rear. The machine is now set to the dimension required. To determine the accuracy of the piece being measured, it is located between the measuring points and the position of the line in the movable spindle noted; if this is not exactly in the center of the two cross-hairs in telescope *B*, wheel *I*, which is divided into 500 parts giving direct readings to 0.001 millimeter, is rotated until the line is directly in the center of the two hair lines. The amount that wheel *I* has been moved away from the zero point indicates the amount that the part varies from the required size in thousandths of a millimeter.

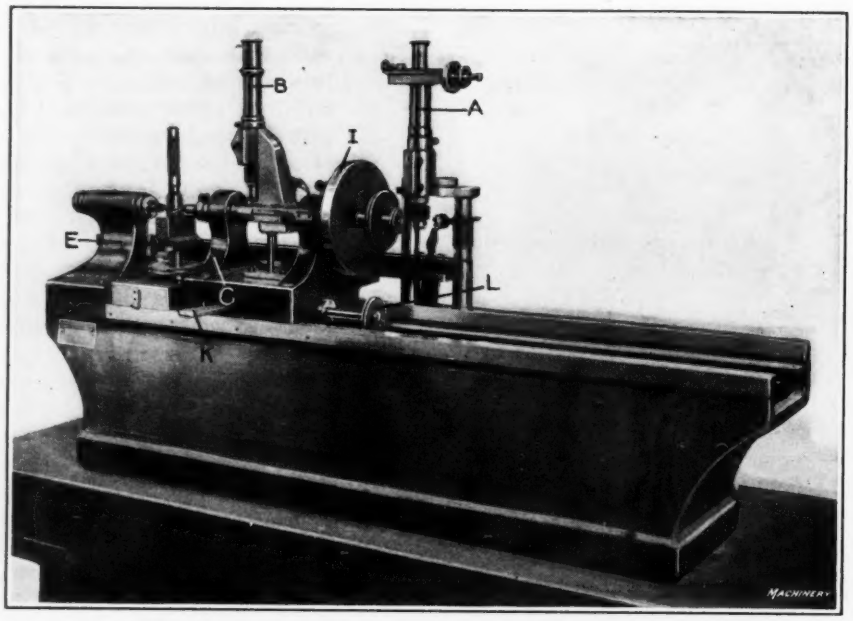


Fig. 14. Swiss Type of Measuring Machine used in Plant of Wells Bros. Co.

Newall Measuring Machine

The measuring machine built by the Newall Engineering Co. of Walthamstow, London, England, is particularly suited for general employment in toolrooms and workshops. It permits of making extremely fine measurements, and is simple in operation. The combined features of the machine are such as to entirely eliminate the possibility of making errors in measuring, and it maintains its accuracy and requires only slight attention for adjustment. As shown in Fig. 16, it consists of a rigidly ribbed bed *A* on which two slides *B* and *C* are mounted. Attached to the bed is a vernier scale *D*, providing for the approximate setting of slide *C*. Slide *C* carries the tail measuring spindle *I* and a

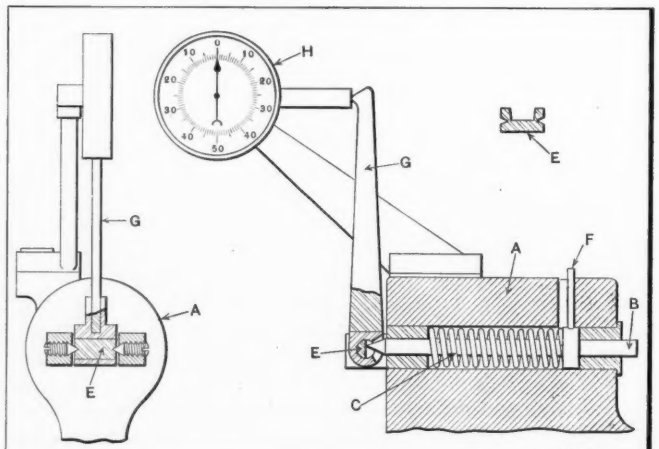


Fig. 13. Diagram showing Pressure Arrangement used on Slocomb Measuring Machine shown in Fig. 12

telescope for setting the position of the slide. In addition, as shown in Fig. 17, it carries an indicating spirit level *E*, which is one of the most interesting features of the machine. When pressure is applied to the measuring anvil through the piece being measured, this spirit level is tilted out of the horizontal plane, due to the backward movement of the anvil; the curvature of the vial gives a movement to the bubble four thousand times the movement of the anvil. This device is so sensitive that the slightest expansion or contraction of the piece being measured, due to varying temperatures, can be detected, and it is more sensitive than the drop plug feeler employed on some of the other measuring machines. The piece to be measured can be supported between the measuring points for any length of time until all parts arrive at an even temperature.

The headstock or slide *B* carrying the measuring wheel gives readings to 0.00001 inch, the graduations on the measuring wheel *F* being so arranged that the indicated size can be read in decimals of an inch, the digits appearing in their proper rotation. For example, as shown in Fig. 18, if the size to be read is 0.31254, the first digit 3 is the highest figure disclosed on the left-hand side of the scale carrying the vernier. The second and third digits 1 and 2 are the highest main graduation on the measuring wheel below the zero line on the vernier, and the fourth digit 5 is the highest sub-division on the measuring wheel below the zero line on the vernier, while the fifth digit 4 is that graduation on the vernier in line with any graduation on the measuring wheel.

The measuring spindle has a thread of the buttress form cut especially deep to provide for wear, and has a range of 1 inch. The threaded portion of the screw and nut is equal to three times the length of range stated, so that the wear is even and accuracy of pitch is maintained. An automatic adjustment is also provided which maintains an even tension on the measuring screw by keeping the effective faces of the screw and nut in contact. It obviates backlash and facilitates accurate reading. A knurled nut on the end of the spindle provides for the rapid movement of the measuring screw. This is used until sufficient pressure has been applied through the piece being measured to bring the indicating bubble into motion. For a sensitive movement, a fine adjusting screw is

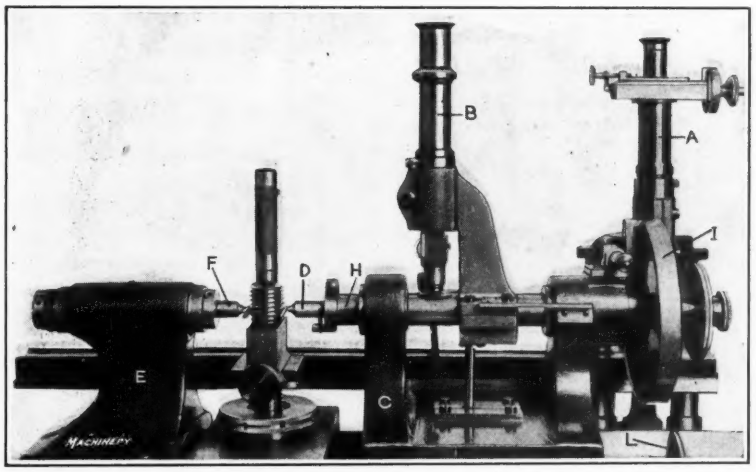


Fig. 15. Close View of Machine in Fig. 14 showing Graduated Wheel and Vernier Scale

provided which is carried on an arm that can be clamped on the measuring wheel at any point by an eccentric. This screw, the thrust of which is taken against the front horizontal bar, gives the slow motion necessary. The front horizontal bar is also used as a stop when it is desired to compare a number of parts which have been made to close dimensions.

Owing to the great difficulty encountered in making the pitch of a screw absolutely accurate for its entire length, a compensator arrangement is provided. This consists of a secondary screw of the same pitch as the measuring screw, cut on the rear end of the spindle. In contact with this screw is a roll held in a lever *G*, Fig. 17, and mounted in such a manner that any undulation on the crest of this thread imparts through lever *G* a forward or backward movement to the vernier scale *H* which is mounted on the vertical arm. In this way any inaccuracies in the pitch of the thread are compensated for.

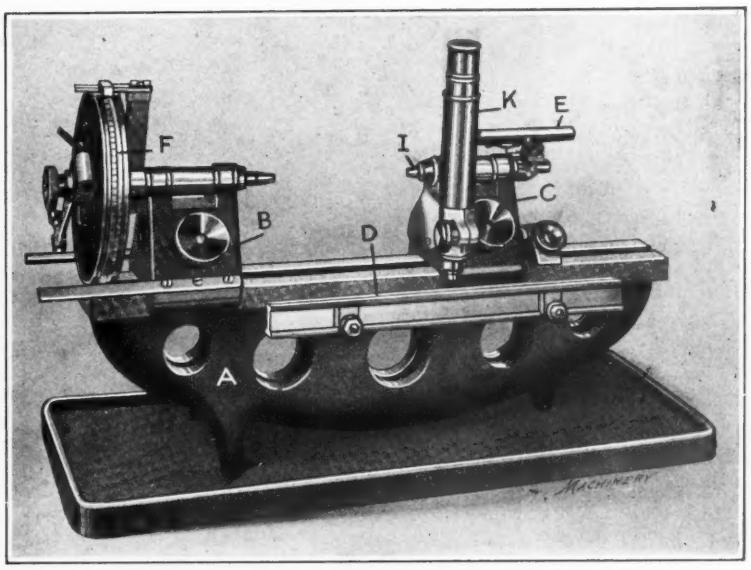


Fig. 16. Newall Standard Type of Measuring Machine

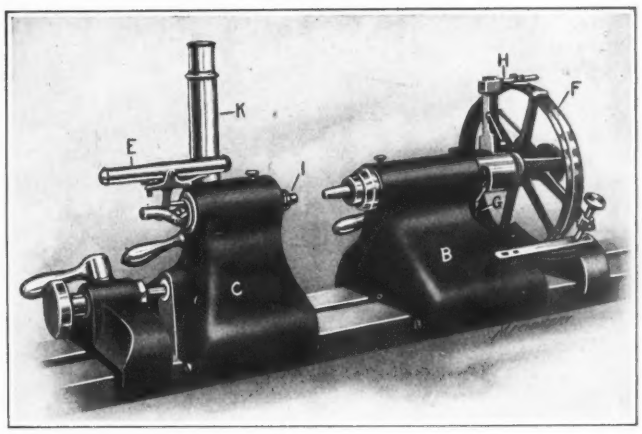


Fig. 17. Close View of Newall Machine showing Spirit Level Indicator and Screw Compensator

Operation of Newall Measuring Machine

In setting this machine, the first step is to ascertain the amount of free movement in the anvil *I*. This is determined by bringing the headstock *B* and tailstock *C* together so that the measuring points may contact, and then observing by rotating the measuring wheel *F* forward, the number of graduations passed in moving the bubble of the spirit level indicator *E* from its resting position. A small adjusting screw is provided underneath the rear end of the vial for returning the bubble to the resting position. Assuming that the free movement of this vial is 0.01 inch, the vertical arm carrying the scale *H* and vernier is swung around to a perpendicular position or inclined a little to the front of the machine if more convenient for the operator's reading and the measuring wheel set to read about 0.01 inch. Before doing this, however, it is necessary to see that the measuring faces of the screw and anvil are perfectly clean and that the headstock and tailstock are securely clamped to the bed. Then the measuring screw is advanced until the indicator bubble again reaches the measuring position and the reading will be somewhere near zero. The vertical arm is then adjusted so as to get the zero graduation on the vernier in direct line with the zero graduation on the measuring wheel, and the machine set at zero. It is advisable, however, to release the measuring screw and advance it again to check this final setting, when any slight inaccuracies may be corrected by a readjustment of the vertical arm. The machine should be so set that it is as free as possible from vibration and also from the effects of frequent changes of temperature. It is essential that it should not be exposed to the direct rays of the sun.

The foregoing description relates to the setting of the machine for measuring pieces up to 1 inch. For measuring pieces over 1 inch and without the use of end measuring rods for setting the machine, the following method should be employed. The tailstock *C* is moved along the bed to the left; then, through microscope *K* it is set to the nearest graduation on the rule on the bed below the size to be measured, the headstock being left untouched, as when previously set to the zero point. In all cases of

microscope settings, it is advisable to clamp the tailstock slightly until, by means of the sensitive movement obtained by the fine adjustment slide, the desired line on the rule is perfectly central between and parallel to the two hair lines in the microscope; then the tailstock can be firmly clamped in position. The part to be measured is held in supports between the measuring points, care being first taken to be sure that all points of contact are perfectly clean. Then by advancing the measuring screw in the same way as has previously been described until the bubble of the indicator assumes its central position, the size of the piece is read off on the wheel and vernier. When advancing the measuring screw, the knurled nut on the end of the spindle is turned until sufficient pressure has been applied to start the bubble from its

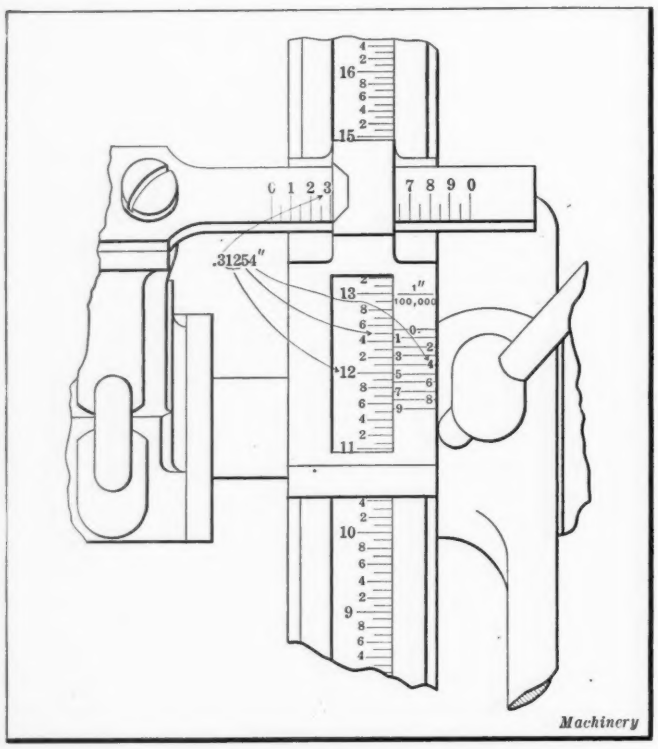


Fig. 18. Diagram illustrating Method of taking Measurements on Newall Measuring Machine

resting position. Then the screw of the fine adjustment arm is turned, moving the bubble slowly to its measuring position, which is the critical point in all operations of setting or measuring. The sub-divisions on the vial of the indicator are intended for comparison only, but their approximate value may be determined by observation and calculation if desired.

Should the alternative method—setting to end measuring rods—be used, a rod of the nearest length to the size to be measured is inserted between the measuring points and the processes described in connection with setting to zero are repeated. The inaccuracy of such end rods must be known, and they should be regularly examined to detect any alterations in length through wear or temperature changes. It is also imperative that all surfaces and working parts of the machine be kept clean and free from oxidization and dust. The lightest possible oil should be used for lubrication, clock oil being preferable, but if this cannot be obtained, paraffine oil should be used on the measuring screw. The accepted mean temperature at which verifications of standards are usually made is 62 degrees F. This is the temperature at which this machine is tested. The rules used on this machine are made in rectangular sections from invar steel, an alloy of nickel steel, which is noncorrosive and practically insusceptible to changes in temperature. This machine will easily measure to 0.000001 inch owing to the extreme sensitiveness of the spirit level indicator.

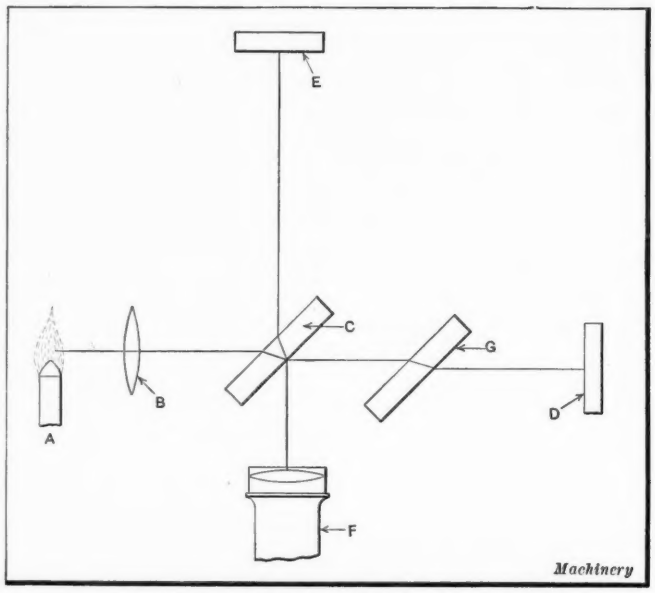


Fig. 19. Diagram illustrating Principle of Interferometer

German Standard Measuring Machine

A measuring machine that is used in the Imperial Laboratory of Technical Tests, Berlin, Germany, and is considered to be absolutely accurate within 0.000004 inch, is shown in Fig. 20. The great precision of this machine is obtained by connecting a movable plunger to a metal diaphragm, which acts upon a colored liquid. This diaphragm is carefully fitted into a cylinder, and connected with the cylinder is a graduated glass tube. The diaphragm is so sensitive that even the expansion of the object being measured caused by touching it with the finger is indicated by the height of the liquid. As far as possible, the temperature of the room is kept at 68 degrees F., and a thermometer forms a necessary part of the instrument. For gaging the work, an adjustable stand is used which is raised to hold the work, if cylindrical, with its axis in perfect alignment with the measuring jaws of the machine. The instrument, in addition, carries a graduated wheel about 10 inches in diameter.

Method of Operating

The chief use of this machine is to compare parts which must be made to standards, and it is therefore not provided with a vernier scale. The method of using it is as follows: The standard test piece with which the parts are to be compared, is brought into contact with screw *A* and plunger *B*,

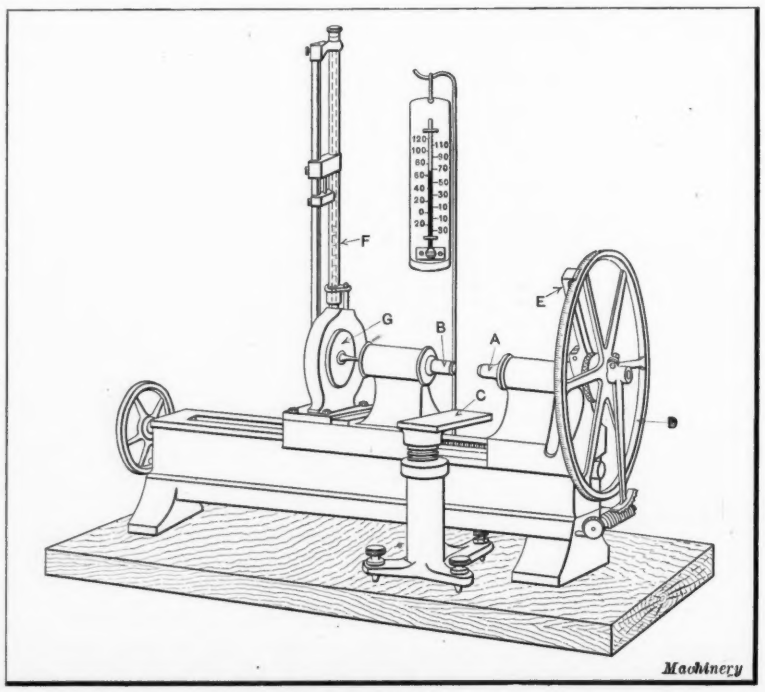


Fig. 20. German Type of Measuring Machine, capable of taking extremely Close Measurements

being supported by stand *C*. Graduated wheel *D* is then set with its zero mark in line with the zero mark on arm *E*, and the height of the liquid in tube *F* is noted. The standard is then removed and the piece to be compared with it substituted. If the difference between the two pieces is minute, the most accurate method of determining it is by the height of the colored liquid, which is so graduated that a difference in diameters is easily calculated. It is highly essential in making accurate measurements that the pieces being measured be of the same temperature as the machine, and hence they should be allowed to remain between the measuring points until this condition is obtained.

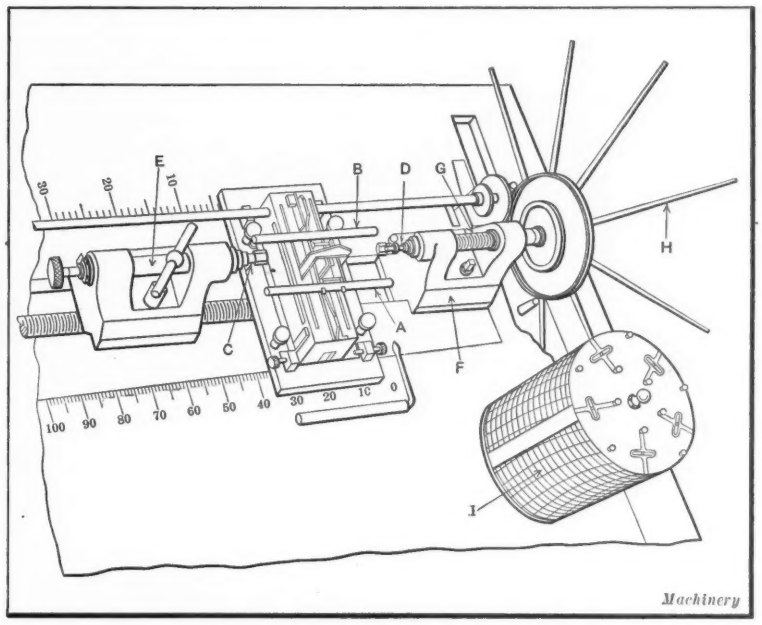


Fig. 21. Hartman's Automatic Comparator

The Hartman Automatic Comparator

The Hartman automatic comparator which is used by the International Bureau of Weights and Measures, France, is employed chiefly for comparing gages, and is not particularly adapted to originating measurements. It was built to insure exactness in the size of gages of the same type which were made by different firms, and is employed largely for testing gages used in gun manufacture. Referring to Fig. 21, which shows a diagram illustrating the principle upon which this machine is constructed, it will be noticed that two end measuring rods *A* and *B* are being compared and are placed between the anvils *C* and *D*. The anvil *C* is held stationary in the tailstock spindle *E*, and the tailstock is free to slide along the base, which is graduated for a length of 1120 millimeters (44 inches). The anvil *D* can be moved backward or forward in the head *F* by means of the left-handed screw *G*, which has a pitch of 1 millimeter (0.039 inch). The rotation of this screw, instead of being noted on a graduated sleeve, is measured by the position of the arms *H* which pass in front of the graduated chart *I*.

The length of these arms is such that they describe a circle of 2 meters (6½ feet) in circumference, while the screw connected with the head makes one revolution and travels a distance of 0.039 inch. The multiplication of the movement of the handles as compared with that of the screw is one to two thousand. By dividing a portion of the circle on the chart into one thousand parts of 2 millimeters each (0.078 inch), when one of the arms has moved that distance—2 millimeters—the surface of the screw will have moved 0.000039 inch.

In comparing the two end measuring gages *A* and *B*, they are placed automatically, alternately between the anvils *C* and *D*, and their lengths registered on the chart *I* by the arms which prick a hole as they pass. The difference between the location of these marks gives exactly the difference between the length of the rods in microns. This instrument is entirely automatic in its operation. The wheel carrying the arms is rotated by a motor which has been greatly reduced in speed. The gages to be measured and supported are held in carriers which operate automatically.

The Interferometer

The interferometer is strictly a laboratory measuring instrument, and while it is indispensable for laboratory use in the checking of standards, it is of little practical value to the average manufacturing establishment. The chief reason for this is that this instrument measures with a degree of accuracy which is much greater than would be necessary in the average manufacturing plant. The interferometer is used for measuring very small distances and angles in terms of wave lengths of light. It has also many other uses which have not a machine shop application. It furnishes the most accurate known method for testing the uniformity of a screw or the perfection of a straightedge, and makes use of the phenomenon known as the interference of light. Light travels in waves, and a simple illustration of this is to compare a light wave to a rope which is fastened at one end and moved up and down rapidly at the other. In the movement of the rope, the distance from the highest part of one wave to the highest part of the next would be a wave length, and the distance which the rope moves up or down from its middle position would be called its amplitude. In the case of light vibrations, the amplitude determines the intensity of the light and the wave length determines the color. For example, light waves which are about 0.00003 inch long appear to the eye as red. The wave length of red light is therefore 0.00003 inch. The wave length of yellow light is about 0.000023, blue light 0.000018 inch, whereas white light is made up of wave lengths

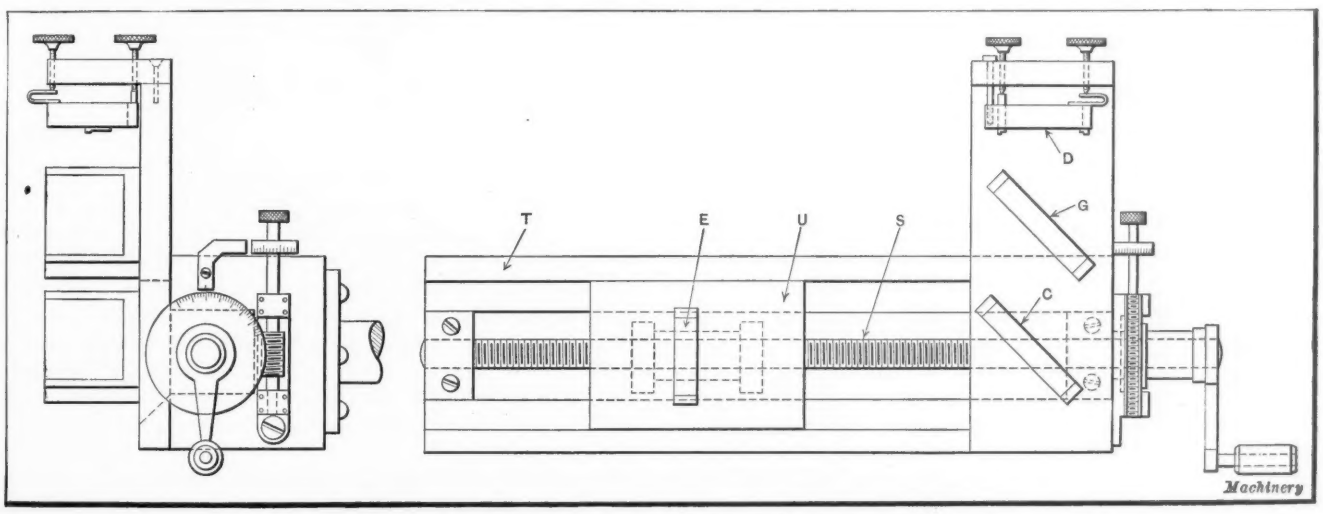


Fig. 22. Modification of Interferometer for testing Accuracy of Screw Threads

of all the primary colors from violet to red. Two pieces of plate glass held in contact may be used to demonstrate the interference of light. If held at an angle to the light, color bands will be noticed in circles and odd shapes throughout the plane of the two surfaces in contact. These colors indicate measurable variations in the surfaces from a true plane.

Principle of the Interferometer

The Michelson interferometer which is employed for precise laboratory measurements in the Bureau of Standards is shown diagrammatically in Fig. 19. Artificial light is used with this instrument to produce the different light waves, which indicate the variations from truth of the planes or other parts being measured. Sodium light, whose wave lengths are about 0.00002 inch, is generally employed. Referring to Fig. 19, *A* is a source of light rays, rendered approximately parallel by the lens *B*, that strike the glass plate *C* at an angle of about 45 degrees. Glass *C* is covered with a semi-transparent coat of silver which transmits some of the light rays to *D* and reflects some to *E*. These beams fall perpendicularly on the highly polished mirrors *D* and *E* and are reflected back to *C*. Some of the rays are reflected from *C*, and others are transmitted through *C* to the observing telescope or to the eye at *F*. The rays which are reflected by mirror *E* have to pass three times through plate *C* before reaching telescope *F*. A compensator plate *G*, is therefore put in the path of the other rays, so that the light reflected by *D* has to pass twice through *G* and once through *C* before it reaches the telescope. Plates *C* and *G* are cut from the same piece of glass in order that they may be of exactly the same thickness, the original piece of glass having been ground and polished until its surface was plane and parallel to within 0.000002 to 0.000005 inch, according to the accuracy of the measurements to be made.

When the paths of light from *C* to *D* and from *C* to *E* have been fixed nearly equal, the mirrors are so adjusted that the color fringes will appear as either horizontal or vertical lines. Then as one of the mirrors is displaced, the color bands will pass in succession before the eye of the observer, who can count them as they pass some point of reference, usually the cross-hairs in the eye piece of a telescope.

Construction of the Interferometer

The interferometer is constructed in different forms, depending upon the class of work for which it is to be used. For instance, an interferometer which would be used for checking the accuracy of angles would be constructed on a different principle from that used for testing the accuracy of straightedges or screw threads. For testing the accuracy of a screw thread, the interferometer would have a form somewhat like that shown in Fig. 22. The screw *S* to be tested is mounted in the bed *T* and is used to move the carriage *U* carrying the mirror *E*. The mirrors are adjusted so that the fringes appear in circles. This will happen when the fixed and movable mirrors *D* and *E*, respectively, are equidistant from plate *C* which divides the light, and when the reflection from mirror *E* in plate *C* is exactly parallel to the face of movable mirror *E*. The variation in the pitch of the screw is determined by the number of fringes that pass through mirror *C*. If the number of fringes is the same for each turn or fractional part of a turn of the screw, the screw is accurate. But if the number varies, the screw is inaccurate, the amount of the inaccuracy depending on the difference in the number of fringes cast. The method of counting the fringes and testing the accuracy of the screw is beyond the scope of this article. It is sufficient to say that by this method inaccuracies are detected in a screw amounting to about 0.0000005 inch.

Reference, Working and Inspection Gages

A SATISFACTORY gaging system should be built around the basic reference and limit snap and plug gages. Reference gages are divided into three classes, as follows: working gages for shop use; inspection gages for final checking; and gages used in testing and adjusting both working and inspection gages. Limit gages include two classes, namely, allowance and tolerance gages. Tolerance gages provide for reasonable error in workmanship, whereas allowance gages take care of the necessary difference in the sizes of two pieces which go together. It should be understood in this connection that the female and male gages are referred to collectively and not individually. Allowance gages are again divided into four distinct classes, depending upon the fit desired—whether running, push, drive or force.

Reference Gages

In addition to the reference blocks and rods shown in Figs. 5 and 6, reference gages are made in several other forms, the most common or conventional type being the standard plug and ring gage shown in Fig. 23. This type of gage is of little or no value in connection with interchangeable manufacture, as it is made to one standard size and can only be used for setting micrometers, calipers and other measuring instruments. Owing to the great accuracy of this gage, it should not be used as a working gage for reasons which will be explained later.

Plug gages are made to standard size within very close limits, and most manufacturers guarantee them to be within 0.0001 inch of standard size, although as a matter of fact

they are made considerably closer than this. The tolerance is over rather than under the standard, so as to provide for wear. The ring gage is then made to fit the plug and is not measured. Theoretically speaking, there is no difference between the diameter of the plug and the diameter of the hole in the ring, and they are put together only with great difficulty by an experienced gage-maker. It is done by coating the plug and the ring with a film of light oil, then getting them into perfect alignment and with a quick twist inserting the plug in the ring. The plug, however, must be kept in motion to prevent it from "freezing." If the ring or the plug is allowed to remain stationary, it will stick to the other

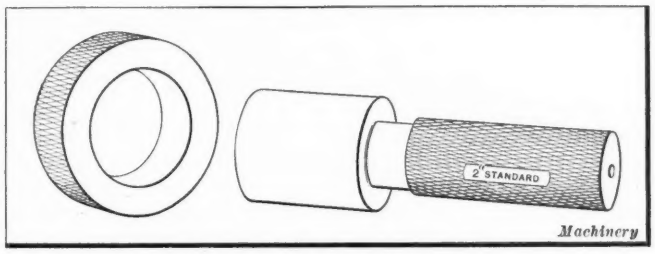


Fig. 23. Reference Plug and Ring Gage

piece in a short space of time, and they can only be separated by force. One way of separating them is to hit the ring quickly on the bench, and before the molecules have a chance to reset, immediately pull the plug out, using a twisting action. This, however, also requires considerable experience.

Reference Limit Gages

As has previously been mentioned, standard plug or ring gages made to one size are of little or no practical value in connection with interchangeable manufacture. Reference gages should be so made that both the inspection and working gages can be checked up by them from time to time, to prevent the limits changing due to the wear of the gages. A practical type of reference plug and snap gage for checking working and inspection snap and plug gages is shown in Fig. 24. Plug *A* has nuts on each end to facilitate lapping and prevent its use as a working gage. The limits are the same as on the working and inspection gages. As will be subsequently explained, it is the practice in some plants to tolerate wider limits on inspection than on working gages. The reason for doing this is to reduce the amount of spoiled work, and also provide for the greater amount of wear on the working gages. When this system is used, it is necessary to provide two sets of limits, one for working and the other for inspection purposes. Reference gages to check the working and inspection gages should, therefore, be made to take care of this. The Johansson blocks can be satisfactorily used for this instead of reference gages.

As an illustration to show how these are used, we will assume that the difference between the "Go" end of the working and inspection gages is 0.0005 inch; that is, the working gage is that amount larger than the inspection gage. The reference snap gage *B*, Fig. 24, can be used to determine when the working gage has worn down this amount; as soon as it has, it is turned over to the inspector, and the workman is supplied with a new gage. In this way the workman is never working to the extreme limits, and the amount of rejected work is thereby greatly reduced.

Manufacturing Tolerances on Reference Gages

Gages which are to be used as standards of reference should be made both carefully and accurately. The permissible manufacturing tolerances are dependent largely upon the class of work for which the gages are to be used, as well as the permanency of the gages. Some manufacturers make their reference standards from a good grade of machinery or tool steel and leave them soft. The reason for this is that soft steel has a lower coefficient of expansion than hardened steel that is not carefully seasoned. Soft reference gages have the one objection that they are subject to wear and are easily dented, and must be handled with care. Owing to the comparatively high coefficient of expansion of carbon steel gages, very close manufacturing tolerances are not feasible. Hence for the finest reference gages invar steel should be used. When this material is hardened and carefully seasoned, the expansion is comparatively low. The well-known Johansson gages are made from this material and are guaranteed to be within a tolerance of 0.00001 inch. As a matter of fact, each individual block is held much closer than this, as a combination of blocks making 8 inches is guaranteed to be accurate to within 0.00004 inch. This extreme accuracy, however, is greater than can be ordinarily expected in regular reference gages, and as a rule the manufacturing tolerances vary from 0.00005 to 0.0001 for sizes up to 1 inch and from 0.0001 to 0.0002 inch for sizes up to 2 inches.

This manufacturing tolerance on the reference gage is distributed so as to take care of the wear on the working and inspection gages which are checked up by the reference gage. For instance, the "Go" ends of a reference plug gage (*A*, Fig. 24) which would be used for checking the "Go" ends of the working and inspection gages would be made to the required size minus the manufacturing tolerance. On the reference snap gage which would be used for testing working and inspection plug gages the manufacturing tolerance would be added to the actual dimension required.

Abuse of Standard Gages

In some manufacturing plants—fortunately not many—it has been the practice to use standard plug and ring gages as working gages. In fact, this has been done to such an extent that a gage on which there is no limit of tolerance is known as a "fixed" gage and is used similar to a caliper. There are two good reasons why a standard plug or ring gage should not be used as a working gage. In the first place, these gages are made very carefully and to extremely close limits, and if used as a working gage, their accuracy would soon be impaired. In the second place, as they are not provided with a working tolerance, a greater amount of time is consumed in getting the work so that the plug will enter or so that the ring will go over it than would be necessary if a regular limit snap or plug gage were used. If both the plug and ring gages were used, they could no longer be considered as standard, as both would become larger from wear. Furthermore, work which is finished so that these gages would fit it would be much more accurate than would ordinarily be necessary, and the time spent in bringing it to this degree of accuracy would be wasted. Therefore, standard snap or plug gages should not be used for other work than setting micrometers, calipers, etc.

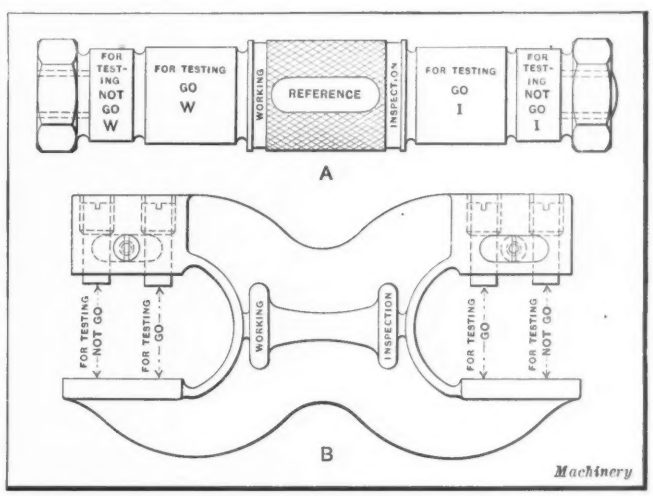


Fig. 24. Reference Limit Gages used in testing Limit Working and Inspection Gages

Limit Working and Inspection Plug and Snap Gages

The most common forms of limit working gages are illustrated by the plug and snap gages shown in Fig. 25. Of course, the form in which these gages are made depends to a considerable extent on the character of the work and, in some cases, on the peculiar fancies of the designer. The two types shown at *A* and *B*, however, illustrate common forms of non-adjustable gages; other varieties will be illustrated and de-

scribed later. The difference between the "Not Go" and "Go" ends on the plug is the maximum error tolerated on the hole, and the difference between the sizes on the two ends of the snap gage, the maximum tolerance that can be permitted on the shaft. The difference between the small end of the plug and the large or "Go" end of the snap gage is the maximum allowance between the two parts—shaft and hole—and the difference between the large end of the plug and the small end of the snap gage is the minimum allowance between the two parts.

Manufacturing Tolerances on Working and Inspection Gages

There seems to be some disagreement between gage manufacturers as regards the manufacturing limits on plug and snap gages. Some manufacturers make all gages within a manufacturing limit of ± 0.0001 inch. This degree of accuracy is not always necessary, and where the work can have considerable tolerance, it is desirable not to make the gages to very close dimensions; it would be preferable to make the plug gage, for instance, slightly large, so as to insure long life. The snap gage would be made correspondingly smaller for the same reason. This practice is being followed by one prominent concern which has adopted a unique system of plug and snap gages. The manufacturing limits on the gages are governed entirely by the limits on the work. For instance, where the work must be held to a limit of within ± 0.0005 inch, the limit on the plug or snap gage would be ± 0.0001 inch. Where the manufacturing limit on the work is 0.002 inch, the limit on the gage would be ± 0.0005 inch. On extremely accurate work, where a limit of only 0.00025 inch is allowed, the gage must be made to a limit of ± 0.00005 inch. This means, of course, that the life of the gage is considerably shortened, and in one instance, where the gage was used for work that was ground, it was found that the gage lasted only one day.

Setting Manufacturing Tolerances on Working and Inspection Gages

As an illustration of the point previously mentioned, Fig. 26 shows a plug and snap gage used in producing a shaft and hole that were required to have a good running fit. In this case, the maximum allowance between the largest shaft and smallest hole is 0.003 inch and the minimum allowance is

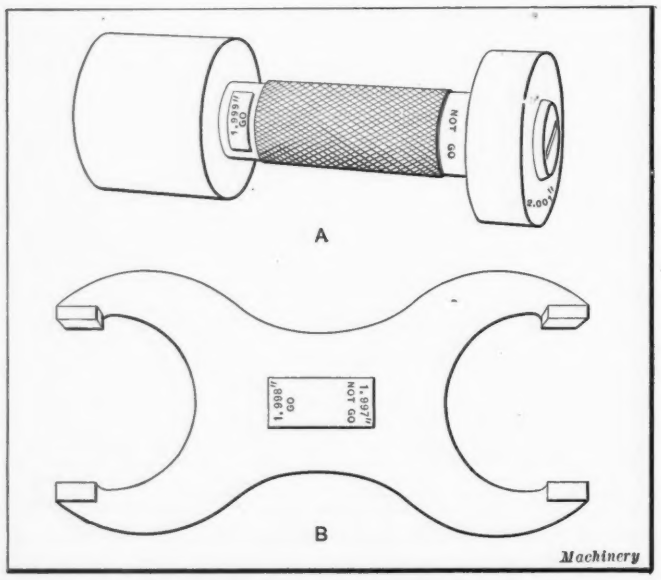


Fig. 25. Limit Working and Inspection Plug and Snap Gages

0.001 inch. The maximum tolerance on the shaft is 0.001 inch and the same tolerance is allowed on the hole. The difference, therefore, between the "Go" and "Not Go" sizes on the snap gage is 0.001 inch. In manufacturing the snap gage, the "Go" portion is made to a manufacturing limit of $0.9985 - 0.0001$ inch $+ 0.0000$. This provides 0.0001 inch for wear before the gage would be worn down to the size indicated. On the "Not Go" end, it is not so important whether the limit is set plus or minus, although it is preferable to have it minus, which would prevent work almost up to the "Not Go" size from going in. On the plug the "Go" end is made 0.0001 inch large to provide for wear, and the "Not Go" end is made this amount small. In this way the manufacturing limits are set so that the life of the gage will be increased without affecting the interchangeability of the work.

Advantages of Tool-setting Gages

In working to limit gages, the tendency is for the operator to work as close as possible to the "Go" end of the gage for fear of spoiling the work. This results in the parts going together with the minimum of freedom. The object, of course, is to make the parts to the mean dimensions. Tool-setting

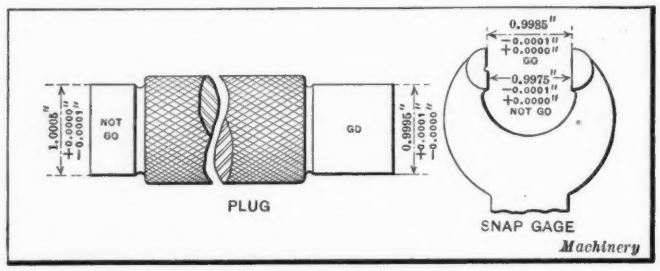


Fig. 26. Diagram illustrating Method of setting Manufacturing Tolerances on Working and Inspection Gages

gages which generally consist of hardened, ground and lapped blocks are used to set the cutting tools, and are made to the "mean dimension." These are used in connection with a hardened and ground locating block on the jig or fixture, and are employed principally on profiling and milling fixtures.

Life of Plug, Ring and Snap Gages

The life of a gage is governed by many conditions, among which might be mentioned: limit of tolerance allowed for wear; condition under which gage is used, whether for manufacturing or inspecting purposes; character of material on which gage is used, whether brass, cast iron, steel, etc.; condition of work on which gage is used, that is, whether rough-turned, finish-ground, lapped, etc.; material from which gage is made, whether cast iron, carbonized machinery steel, tool steel, malleable iron, etc.; condition of measuring surface on gage, whether ground or highly finished and lapped; care used in applying gage.

Limits of Tolerance Provided for Wear

As has been previously mentioned, limit gages are usually made with manufacturing limits that increase the life of the gage. In other words, on a plug gage, the "Go" end is made with a manufacturing limit larger than the size specified on the gage. The amount of this limit, in a general way, determines the life of the gage. As a case in point, on one extremely accurate piece of work a limit of 0.00025 inch was the greatest tolerance. The plug gage was therefore made with a plus wear limit of 0.00005 inch, and as this gage was used in testing a hole finished by grinding, where considerable grit and dirt accumulated, its life was only one day of ten hours. In other words, a new gage had to be furnished every day. This, however, is an exceptional case, but it serves to illustrate the necessity of setting manufacturing limits on the gage to provide for wear. The greater the limits on the work, the larger can be the permissible tolerance for wear on the gage, so as to increase its life as much as possible. Furthermore, when the "Go" end of a plug gage, for instance, is made larger than the lowest limit of tolerance, the machine operator is working closer to the mean or nominal dimension. In purchasing gages most manufacturers do not give the subject of wear the attention it deserves, and generally hold the gage-maker right down to the sizes given, which of course do not provide for wear. This results in greatly increasing the gaging and inspection expense.

Conditions Under Which Gages Are Used

The conditions under which a gage is used, that is, whether it is used for manufacturing or inspection purposes, governs to a large extent the number of pieces that can be gaged. It is, therefore, the practice of some firms to permit a larger

manufacturing limit on the working than on the inspection gages, and then interchange these gages as they begin to wear. For example, in one plant the machine operator is given the newest gage when it is of the plug variety, and the oldest when of the snap variety (solid type), and to keep close watch on the condition of the gages, this firm employs several men, known as "field" inspectors. The duties of these men are to cover the entire plant, inspecting the gages and replacing those that are worn out by new gages adapted to the work. When a job is turned in and the gages and tools sent with it, these gages are not allowed to be put in the tool storage or supply room, but are handed over to the field inspectors, who carefully go over the gages before they are stored. These field inspectors also see that the production and inspection departments are supplied with the proper gages. In this way, the machine operator is always provided with a gage with the closest limits, and consequently the greatest amount of wear is obtained from the gages. Gages wear much more rapidly, of course, when used for manufacturing than when used for inspection purposes, so that the interchange of gages greatly reduces the amount of rejected work.

Influence of Material Being Gaged on Life of Gages

The kind of material being gaged also has considerable bearing on the number of pieces that can be gaged before the gage is worn beyond the required limits. Some materials, such as cast iron and particularly aluminum, have a lapping effect and wear the gage down much more rapidly than either brass or steel. In one plant where a large number of aluminum fuse parts are being manufactured, a careful inspection of the gages proved that in gaging 10,000 aluminum parts the wear on the gage was 0.0005 inch. It was also found that five times as many brass parts could be turned out with the same amount of gage wear as aluminum parts; in other words, the same gage used on brass would inspect 50,000 parts before it was worn 0.0005 inch. Cast iron has a lapping effect somewhat similar to that of aluminum, but not so pronounced. In gaging cast iron, about 20,000 parts can be turned out with a wear of 0.0005 inch on the gage. The wear, of course, depends to a considerable extent on the diameter of the work and the condition in which it is received when being gaged.

Influence of Condition of Work on Wear of Gages

The condition of the work—whether rough or smooth—also has a governing effect on the life of the gage. Rough-turned work will wear a gage down much more rapidly than a ground surface, free from grit. As an indication of the life of an ordinary snap gage on work that is ground fairly smooth, it was found in one plant where a careful record was kept that 35,000 Russian shrapnel shells having a ground surface could be inspected with one gage before it was worn beyond the required limit. In this particular gage, 0.002 inch was allowed for wear, so that the gaging of 35,000 shells removed this amount of material from the surface of the measuring point on the gage. In this plant it was also found that solid snap gages did not give nearly as satisfactory service as those that were made with adjustable points. The latter could be readjusted every day to a standard plug, and the life, of course, could thereby be greatly increased. In another plant where a similar limit was allowed on the gage and where the work was turned instead of ground, the number of parts inspected varied between 8000 and 10,000 before the 0.002 inch limit was removed from the surface of the gage. From this it will be seen that ground work has not nearly as abrasive an effect on the gage surface as rough-turned work. In other words, a gage can be used for only about one-third as many rough-turned pieces as ground pieces.

Material Used for Gages

Gage-makers differ to a considerable extent in regard to the material from which gages should be made and its bearing upon the life of the gage. There are so many points to take into consideration in this connection that it is difficult to reach any definite conclusion. For instance, one point that must be considered is the total number of parts to be gaged; another, the limits on the gage which would make it unnecessary to inspect every part; still another, whether the gage is to be used for reference, working or inspection purposes. It is generally conceded, however, that for plug gages used for manufacturing purposes, it is preferable either to make the gage from a good grade of machinery steel and carbonize it or to make it from tool steel hardened, seasoned, ground and lapped. Gages are seldom left soft unless they are used for reference purposes or unless only a few parts are to be inspected. It is also the practice to leave thread gages soft; this point will be taken up under a separate heading.

The type of gage also has an important influence on the selection of material from which it should be made. For instance, a solid snap gage is seldom made from cast iron, either a malleable casting or a steel forging being used. Most manufacturers of solid snap gages make them from drop-forgings, when they are used for measuring up to 3 inches in diameter. Above this size, the gages are made from steel castings which are heat-treated, seasoned, ground and lapped to size. When snap gages are provided with adjustable points, it is the general practice to make the frame either from malleable castings or from cast iron. One prominent manufacturer of snap gages follows the practice of making the frame from cast iron of frail dimensions. This is done so that in case the gage is dropped on the floor, the frame will break rather than distort. In this way any chance of the operator distorting his gage without knowing it is eliminated. The frame is also made of such a shape that it is impossible for the operator to "peen" the gage to fit the work. The difference between the lives of a solid snap gage made from fine-grained cast iron and one made from hardened steel is considered by many gage-makers to be extremely slight.

Relation of Measuring Surface and Life of Gages

The condition of the measuring surface on the gage is not always considered a vital factor affecting the life of the gage. When it is understood, however, that it is practically impossible to secure a perfectly plane surface, the question of securing a smooth surface on the gage appears to be of greater importance. Some gages, especially the Johansson gages, have the property of sticking when wrung together with a force considerably greater than that due to atmospheric pressure on the areas in contact.

This phenomenon has been attributed to molecular attraction, but investigation has shown that the adhesion is due to the presence of a very thin liquid film. Blocks made from hardened steel were prepared, each weighing an ounce and a half and having surfaces 0.7 square inch, polished flat to within 1/100,000 inch of being a true plane. These blocks were then used to test the adhesive properties of different liquids. The contact faces were carefully freed from moisture and cleaned with alcohol. When the blocks were wrung together, they fell apart under their own weight, but as soon as a film of oil or other liquid was put between them, a force of 17 pounds for Rangoon oil, 20 pounds for lubricating oil, 29 for turpentine, and 35 for condensed water vapor was required to separate the blocks. From this test it was proved that it is impossible to get perfect union between two parts, and the only reason that they held together was because of the adhesive qualities of the lubricant or other liquid. Any machined surface, no matter how smooth, consists of humps and hollows so that a surface which is brought down to the closest approximation of a true plane is one in which there would be the greatest number of points in a common plane. It is therefore reasonable to assume that a gage made with a smooth measuring surface will wear much longer than one made with a rough surface.

Care Used in Applying Gages

It has been previously stated that gages used for inspection purposes wear much longer than those used as working gages. One reason for this is that the inspectors handle the gages much more carefully than the workmen do. In the first place, an inspector is seldom put on a piece-work basis, whereas a machine operator usually is. The chief point with the workman is to turn out as many parts as he can in the shortest possible time. To show that this is the case, a prominent

concern made a careful test of the gages used by an experienced inspector and found that in inspecting 130,000 pieces, the different gages were worn from 0.0015 to 0.003 inch. Similar gages used for manufacturing purposes were found to wear only one-half as long as those used in the inspection department.

Life of Gages Used on Ammunition Work

The production of munitions in this country has caused considerable attention to be paid to interchangeable manufacture and the use of limit gages. Parts for shells, fuses, etc., have been made by several different firms and then assembled in a separate plant, so that each part had to be made a duplicate of the other in order to have them go together without fitting. This necessitated each plant being equipped with a complete set of limit working and inspection gages.

Several interesting points have come up in connection with the design and use of gages, one of which is the length of time that a gage can be used before it is worn beyond the set limits of tolerance. Some manufacturers did not equip their plants with the necessary number of reserve gages, with the result that they had to wait for a considerable length of time to get deliveries from gage manufacturers. On account of this trouble a close record was kept of the life of various gages, so that considerable data were soon available. Wells Bros. Co. of Greenfield collected a large amount of information on this subject, some of which is presented in Table IV. The number of pieces tested by the various gages is based on data obtained from various munition manufacturers and represents a safe estimate of the approximate life. It should be noted in this connection that in very few cases were the gages provided with any tolerance for wear, so that their life was considerably shorter than would have been the case if a percentage of the manufacturing tolerance on the work had been placed on the gage.

Types of Plug Gages

Plug gages are made in a variety of forms and sizes, depending largely on the shape and size of the work to be measured. For gaging small holes, they are generally made from a solid piece of steel, whereas for gaging larger holes they are built up and so constructed as to make them easy to handle. A reference standard plug gage of the type shown at *A* in Fig. 27 is used chiefly for sizes up to 1 inch in diameter. For larger sizes, the gage generally has the form shown at *B*, and is made of flat section from either a drop-forging or a steel casting, ground and lapped on the circular contour. The gages shown at *A* and *B*, respectively, should not be used for working or inspection gages, but merely for reference purposes. Gages used for working or inspection purposes should be provided with certain tolerances, depending on the character of the work.

C is a simple form of limit plug gage for comparatively small work. This consists of a hexagon handle provided with tapered holes in each end, into which hardened, ground and lapped plugs are fitted. The "Go" plug is made considerably longer than the "Not Go" plug, to distinguish between them. Another type of plug gage shown at *D* is used for work of larger diameter, generally up to about 1 inch. This gage also has one end longer than the other, the longer being the "Go" end of the gage. When a gage of this type is being used on a grinding machine, the operator does not know how much material is to be removed until the "Go" end enters the work. For this reason, it is the practice in some plants to taper the "Go" end of the gage as indicated by the dotted lines *a*, making the end from 0.005 to 0.010 inch smaller than the regular "Go" size or straight portion. This enables the operator to enter the gage into the work practically after he has taken his first roughing cut, and he can thus work much more rapidly; the chances of grinding the hole too large are also reduced, and at the same time the gage does not have to be used so frequently. When a plug gage of this kind is used, it is advisable to have the limit on the "Go" end as close as possible to the mean dimension and have the greater amount of tolerance on the "Not Go" end. The reason for this is that it is easier for the operator to work to the "Go" end with this type of gage, and as it is the mean dimension that is always

TABLE IV. ESTIMATED LIFE OF GAGES USED FOR 4.7-INCH HIGH-EXPLOSIVE SHELLS

Operation	Type of Gage	Estimated Life—Pieces Gaged
Rough Blank		
Length of billet	Crescent	100,000
Diameter of billet	Crescent	100,000
Forged Blank		
Diameter and length	Templet, snap	10,000
Cavity	Plug, flat	10,000
Diameter	Crescent	100,000
Wall thickness	Caliper	50,000
Length, total	Flat hook	100,000
Shell Body		
Trim base	Plunger, depth	30,000
Trim length	Fixture	30,000
Form nose	Flat, profile	11,000
Nose diameter	Crescent	100,000
Nose diameter	Ring	25,000
Body diameter	Crescent	100,000
Base diameter	Crescent	100,000
Band groove	Crescent	100,000
Base groove	Crescent, special point	100,000
Base groove	Flat, snap	5,000
Base groove	Flat, profile	11,000
Crimping groove	Flat, profile	11,000
Band groove	Flat, profile	11,000
Width band groove	Flat, limit	25,000
Base to bourrelet	Flat, profile	100,000
Bore for thread	Limit, plug	25,000
Thread recess	Flat, location	11,000
Thread plug	Limit	4,000
Counterbore	Limit, plug	25,000
Wall thickness	Concentric special	50,000
Band profile	Flat, limit	11,000
Base diameter	Ring gage	25,000
Diameter over band	Ring gage	25,000
Band		
Cut length	Fork, limit	100,000
Wall thickness	Fork, limit	100,000
Chamfer	Flat, profile	11,000
Hole	Plug, limit	25,000
Base Plug		
Large diameter	Crescent	100,000
Thread diameter	Crescent	100,000
Concentricity diameter	Thread ring	20,000
Thread and groove	Crescent	100,000
Length thread and head	Flat, profile	11,000
Counterbore	Limit, cylinder plug	25,000
Thread bore	Limit, cylinder plug	25,000
Thread	Limit thread plug	4,000
Thread and groove	Flat, location	11,000
Depth and width, slot	Special plug	25,000
Outer thread diameter	Crescent, thread	100,000
Iron or Bronze Fuse Hole Plug		
Head diameter	Fork, limit	100,000
Flat for wrench	New Corey, limit	100,000
Thread and groove	Fork, special point	100,000
Thread O. D.	Fork, limit	100,000
Concentricity	Ring, thread templet	20,000
Length and shoulder	Flat, limit	11,000
Internal thread groove	Flat, limit	11,000
Thread size	Fork, thread	100,000
(Alternative) Die-cast Fuse Hole Plug		
Head diameter	Fork, limit	100,000
Socket	Plug, limit	25,000
Thread diameter	Fork, limit	100,000
Concentricity	Ring thread templet	20,000
Thread I. groove	Fork, special point	100,000
Length and shoulder	Flat, limit	11,000
Thread size	Fork, thread	100,000

Machinery

desired, it is advisable to have the limit here as close as practicable. Say, for instance, that the total tolerance between the "Go" and "Not Go" ends is 0.002 inch; then the limit on the "Go" end should be 0.00025 inch below the mean dimension and the remainder of the tolerance should be on the "Not Go" end.

It is the practice of some manufacturers to make a gage of this sort single-ended and use the taper as a limit. This practice is not recommended for the reason that if the cylindrical part of the gage enters the hole, it would be too large. Consequently, it is necessary to have the plug enter about half way up on the taper. This does not give the operator a chance to tell whether he has a bell-mouthed hole or not. Neither does it give him a chance to tell whether the hole is truly cylindrical or tapered unless he removes it from the chuck and tests both ends. It is preferable when using a gage with a tapered end to have the taper on the "Go" end and the cylindrical part as close as possible to the mean dimension, as previously stated.

When the work has a hole passing through it, the plug gage is sometimes made of the type shown at *E*. This gage has an advantage over that shown at *D* in that the "Go" and "Not Go" sizes are on the same end of the gage, so the operator is not likely to use one for the other. In order to facilitate grinding a hole to the correct size, the end of this plug gage can be tapered similarly to that shown by the dotted lines *a*.

An improvement over the gage shown at *E* is shown at *F;* this gage, of course, can only be used where the hole passes completely through the work. Here the gage is provided with three dimensions, one the "Go," one the "mean" or exact dimension desired and the other the "Not Go." In all manufacturing, especially on close work, the mean dimension is the one desired, and having a gage made with the three sizes, low, mean and high on one end, it is easy for the operator to work to extremely close limits with comparatively little trouble.

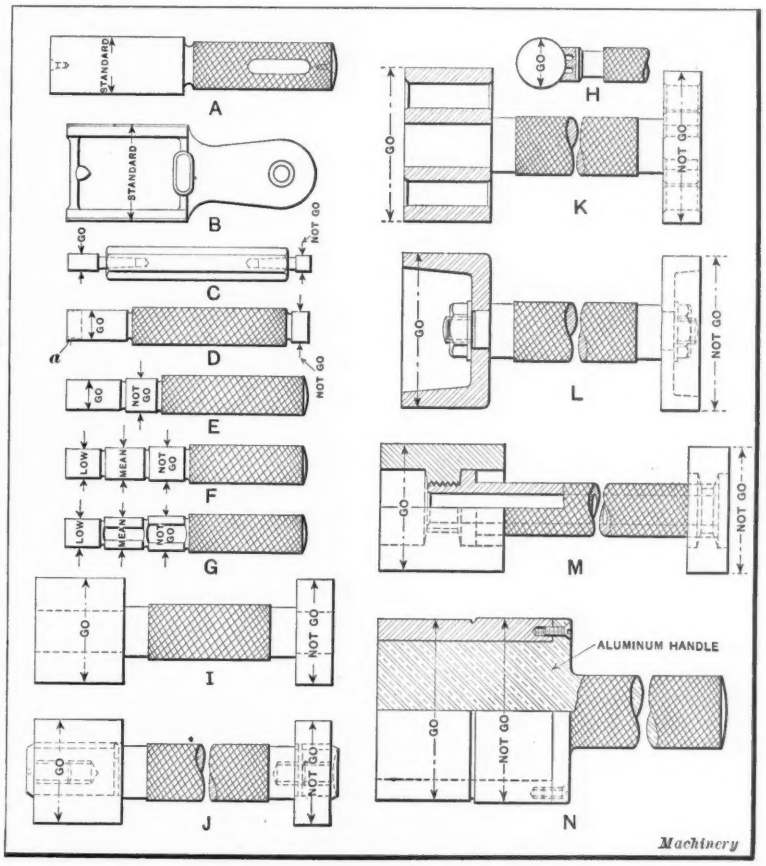


Fig. 27. Types of Plug Gages

As a matter of fact, however, the plug gage is not a true detector of all the errors in the hole; for instance, a plug gage will not indicate whether the hole is truly cylindrical or not. It merely tests whether the hole is of the required size at a certain point, and for the majority of work this is sufficient. With a plug gage made as shown at *G* it is possible to tell whether the hole is round or not within the required limit. The "mean" and "Not Go" shoulders are ground flat as shown, so that only two points of the circumference are up to the required size. By turning the gage around, it is possible to determine the truth of the hole. This gage has been found satisfactory where an extra degree of refinement is necessary and where the hole is not three-cornered.

The gages shown from *C* to *G* are for inspecting small sized holes up to 1 inch in diameter. When the holes are greater in diameter, a built-up gage is preferable in order to economize in stock. One type of built-up gage is shown at *I*. This, as will be seen, consists of "Go" and "Not Go" cylindrical plugs fitted onto a soft steel shank by simply having the turned down end of the shank slightly tapered and driving the rings on. This is a comparatively cheap gage to manufacture and is satisfactory for the majority of work. Another type of built-up plug gage for large work is shown at *J*. In this case, the handle is made an easy fit in the holes of the "Go" and "Not Go" plugs; the latter are fastened to the handle by means of screws, as shown, and are prevented from turning by pins which fit in a slot in the hole in the plug. This type of gage is a little more expensive to manufacture than the type shown at *I*, but there is little danger of the plugs turning around or coming off while in the work.

K shows a type of plug gage for gaging very large holes. The "Go" and "Not Go" plugs are lightened by drilling six holes around the plugs midway between the outer circumference and the hole. A gage of this type must be carefully hardened to prevent cracking, and also seasoned to eliminate any internal strains that might develop after the gage had been in use.

An unsuccessful attempt to lighten a plug gage is shown at *L*. This type of gage has many disadvantages, one of which is the difficulty of hardening without springing it out of shape. Also, owing to the unequal strains set up in hardening, which are only partially removed by annealing, it will not retain its shape when in use, and soon becomes out of round and inaccurate. It is also affected considerably by temperature changes. A plug gage of this shape which is held in the hand for a few minutes will be found to be out of round about a half-thousandth inch, simply because of the strains set up and the lack of sufficient support, on the extreme outer end. This gage is much lighter than the solid gage, but the objections are so great that it is not recommended, although it has been used to some extent.

A gage which is made in a somewhat similar manner, but is so constructed that the strains are equally divided, is shown at *M*. Here it will be noticed that the "Go" and "Not Go" plugs are counterbored, and the mass of material is in the center. In hardening, the strains are more equally distributed throughout the mass, and by careful annealing and seasoning, can be practically eliminated. The gage is also lightened by making the handle hollow, as shown. This type of construction is used by C. E. Johansson, maker of the well-known Johansson block gages. The hollow handles allow the air to pass through the gage when gaging blind holes, and the plugs are reversible, insuring double life. The measuring plugs are made of high-carbon Swedish crucible steel, hardened clear through and tempered and seasoned. The operations on these plugs consist in hand-forging, roughing to shape, hardening, rough-grinding, seasoning for a long period, and finally grinding and lapping. It is also claimed by this concern that making gages from low-carbon steel, casehardened, is unsatisfactory, due to two causes. One is the rapid method of seasoning generally followed, and the other the constant pulling of the hard case on the soft core. Gages that are hardened all through and carefully seasoned are not so likely to change as those are are casehardened and improperly seasoned.

Very large plug gages are made of a type somewhat similar to that shown at *B*, except that they are provided with two diameters giving the plus and minus limits; or they are made of the bushing type shown at *N*, having an aluminum core and handle. A gage made of this type must be carefully hardened, and seasoned for a considerable period. It is also inadvisable to drive the sleeve onto the aluminum core. A preferable method is to hold the sleeve on the aluminum core by means of screws, as shown. This prevents distortion of the ring. The ring, of course, should be finish-ground and lapped while it is attached to the aluminum core, so as to prevent any liability of distorting it by assembling after lapping.

Another plug gage which is comparatively cheap to manufacture, and also very accurate, is shown at *H*. This consists of two balls which are electrically welded to a handle, as shown. This gage has one serious disadvantage, in that its life is comparatively short, owing to the line contact which it presents to the work. There are many other types of plug gages used in various plants, but those shown in the foregoing illustrate the general principles of construction.

shown at *D*. This gage is made in two principal forms, one being shown by the full outline and the other by the dotted outline *a*. The dotted outline type of gage is used when the diameter to be measured is greater than 1 inch. Making a gage to this shape lightens it considerably. A single-ended type of limit gage is illustrated at *E*. This is provided with one flat jaw and one having the permissible tolerance on it. Gages of this kind are usually made from drop-forgings and hardened. *F* shows a limit snap gage in which the body is made from cast iron with solid measuring points inserted. This gage is not provided with any adjustment, and it is necessary to renew the points when they become worn. This type is used only on very large work.

Another type of limit gage having only one jaw, but being provided with adjustable points, is shown at *G*. The adjustable points are prevented from turning in the holder by means of screws, as shown, the points having a flat side against which the heads of the screws rest. The anvils are adjusted in and out by means of the headless screws and are clamped by the screws passing through at right angles to the axis of the anvils. The forward faces of these anvils are beveled to

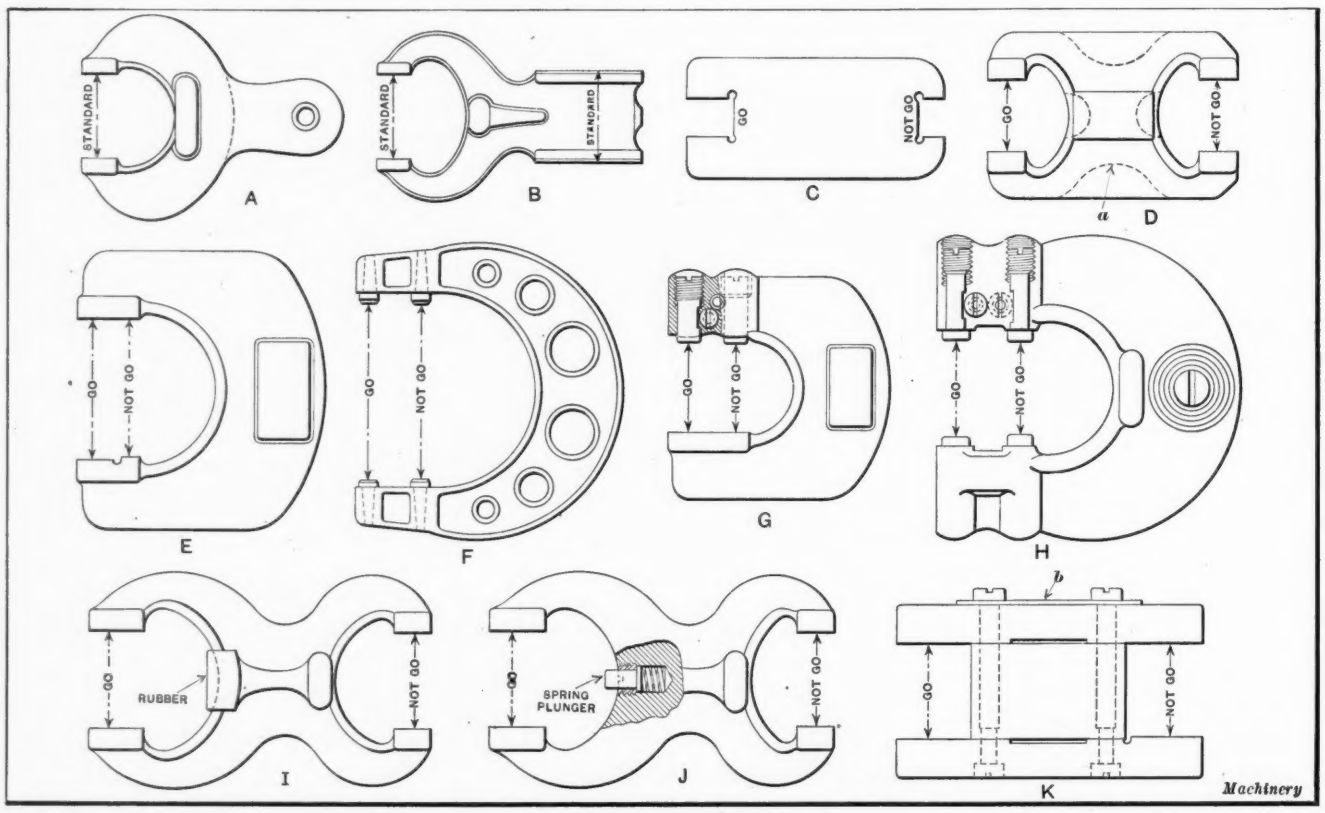


Fig. 28. Types of Snap Gages

Types of Snap Gages

Snap gages used in general manufacturing are made in three types, namely, solid, adjustable and built-up gages. The adjustable type consists of a frame having adjustable anvils, and the built-up type is made from separate blocks. One type of snap gage, which is shown at *A* in Fig. 28, is known as a standard or reference gage. This gage is not provided with any working limit and is made to standard size, being used for reference purposes only. It is usually made from a high-carbon steel forging, carefully hardened, seasoned, ground on the measuring faces and lapped. As has been previously stated, the use of this gage for other than reference purposes should be discouraged.

A type of gage which is a combination of snap and plug gages is shown at *B*. This is made and used in the same way as gage *A*. *C* shows a common type of limit snap gage which is made from sheet steel, varying in thickness from ¼ to ½ inch, depending on the diameter and character of the work being gaged. Snap gages of this type should have as wide a bearing surface as possible, as this greatly increases their life.

Another type of limit snap gage which is usually made from a forging, although sometimes from a malleable casting, is prevent marking the work. Usually on an adjustable snap gage of this kind the points are not made absolutely flat, but are slightly convex. This insures that the measurement is always taken directly on the axis of the plug.

Still another type of adjustable point measuring gage in which all four measuring points are adjustable is shown at *H*. This type of gage is the Johansson patented limit adjustable snap gage. The measuring plugs are not threaded and do not turn in the body, having an end movement only which prevents any possibility of their becoming cocked, as is the case with threaded plugs. They consist of plain cylinders of hardened steel, with flats on one side, and are lapped a snug, sliding fit in the lapped holes in the body. The ends which come in contact with the work and the faces of the adjusting screws are lapped square with the axis. The flat surface on the plugs and clamping screws prevent the plugs from turning in the body when adjustments are being made. The rear end of each adjusting screw is provided with a screwdriver slot, and the forward ends which come in contact with the plugs are lapped square with the axis. These screws should be sealed by the inspector after the gage has been set to prevent the workmen tampering with it. The clamping screws

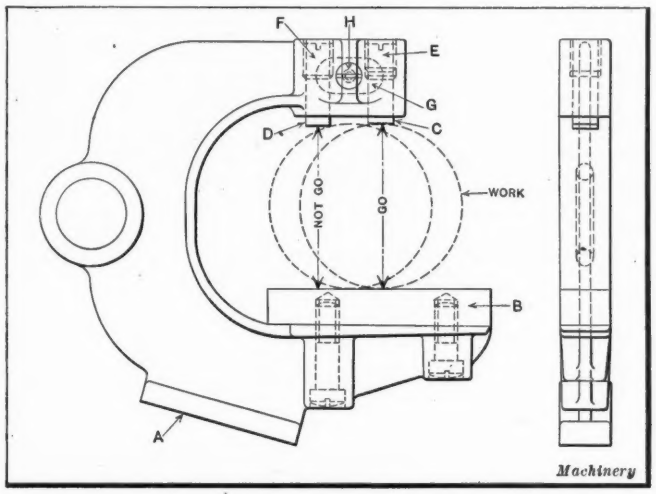


Fig. 29. Wells Bros. Co.'s Rapid Inspection Limit Snap Gage

are so arranged that they not only clamp the plugs, but also tend to force them to a seat on the adjusting screws. The body of the gage is made from an iron casting of comparatively frail dimensions, so that if it should be dropped, it is more likely to break than to be distorted. The frame is also provided with an insulated rubber grip to prevent the heat of the hand from affecting the accuracy of the gage. By holding the gage with two fingers on the insulated grip, a sensitive touch can be attained, and at the same time the gage will not be distorted by the heat from the hand.

In using double-ended limit gages of the type shown at *D*, where the "Go" end passes over the work, the gage will soon become inaccurate unless handled carefully, owing to the hammer effect on the throat of the gage when it hits the work. This causes a peening action which gradually opens the jaws. Different devices have been used for overcoming this. One, which is shown at *I*, consists in using a rubber pad fastened to the throat of the gage, as indicated. This takes the shock of impact of the gage on the work and prevents the peening action. Another method is shown at *J*, which consists of inserting a spring plunger in the throat of the "Go" end of the gage. The "Not Go" end, of course, need not be made in this manner, as it is not supposed to pass over the work.

Rapid Inspection Limit Snap Gage

A type of limit snap gage provided with an extension jaw, and which can be used either as a working or inspection gage, is shown in Fig. 29. This gage, which is patented by Wells Bros. Co., Greenfield, Mass., consists of a frame carrying a hardened, ground and lapped anvil plate and two adjustable measuring points. For snap gages having a capacity up to 1¼ inch, the frame is made from a drop-forging, while for larger sizes malleable castings are used. Cast-iron frames were tried, but it was found that they did not always break when dropped on the floor, but sometimes became distorted slightly. Consequently it was decided to make the frame from either a drop-forging or a malleable casting.

Referring to Fig. 29, it will be noticed that in the rear end of the frame is a hole which is elongated on the larger sizes to facilitate holding; there is also an extension base *A*, which can be used for holding the gage in a stand when it is desired to use it for inspection purposes. The lower jaw carries a hardened, ground and lapped anvil *B*, which is held in place by two screws as shown. This anvil greatly facilitates the location of the gage on the work, and makes rapid inspection possible. The measuring points *C* and *D* for the "Go" and "Not Go" sizes, respectively, are hardened, ground and lapped on the circumference and ends. The plugs are adjusted by screws *E* and *F*, and are clamped by a bar *G* and screw *H*.

Built-up Limit Snap Gages

In many plants, and especially in those industries where a limit gage system is used extensively, considerable use is made of the built-up type of snap gage, one form of which is shown at *K* in Fig. 28. This gage consists of three members—one center spacing block and two measuring blocks. The form in which these measuring blocks are made differs in various plants. In some cases, one of the measuring blocks is split in half and the limit provided by grinding down half the center block the required amount for the "Not Go" end. The other system which is shown at *K* consists in having the limits on one of the measuring blocks. This type of gage is comparatively cheap to manufacture, as it can be finished complete on the surface grinder and is easily built up and torn down for different sizes; it is only necessary to change the center block and the tolerance on one of the side blocks to adapt it for different sizes. A brass plate *b* is fastened under the head of the screws to carry the job number and any other necessary data. It is the practice in some plants to put the "Go" and "Not Go" dimensions on this piece, so that the operator knows what dimensions he is working to. Usually, however, this piece simply carries the job number, and is substituted by another when the gage is built up for a different size.

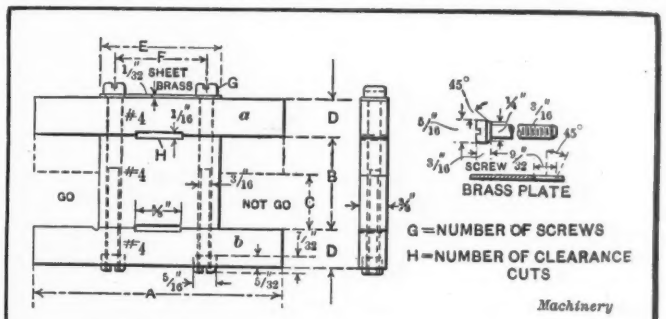
Proportions for Built-up Limit Snap Gages

Table V gives proportions for standard parts of built-up snap gages of the type shown at *K* in Fig. 28. This gage, as the table shows, is made in five sizes. The spacing blocks are made from machinery steel and vary in thickness by 1/32 inch; that is, the space between the maximum and minimum sizes *B* and *C* for each number of gage is divided into thirty-seconds of an inch. Hence, eight spacing blocks would be needed for gage No. 2. These spacing blocks are casehardened and ground and have the size stamped in the clearance cut. The top block *a* is ground perfectly parallel, while the bottom block *b* is made to provide for the manufacturing tolerance on the work and is stamped accordingly. Both these blocks are made from tool steel and hardened. When a snap gage of a certain size is desired, two blocks *a* and *b* and a spacer of the required thickness are obtained from the store-room and fastened together by screws which are standardized. A brass nameplate carrying the piece and operation numbers is put on, thus obviating the stamping of the gage proper; when worn, the gage can be taken apart, ground, lapped and put together again, and used indefinitely. The advantages of this type of snap gage for interchangeable manufacturing are obvious.

Taper Plug and Ring Gages

The measuring of taper holes is practically always a fitting proposition. In fitting taper parts, the points that receive attention are the degree of taper per foot or inch, and the relative longitudinal positions of the two parts which go together. In making a taper fit, the largest diameter of the hole and the largest diameter of the shaft must correspond within certain limits, these limits being taken lengthwise with

TABLE V. PROPORTIONS FOR BUILT-UP LIMIT SNAP GAGES



No. of Gage	Dimensions in Inches							
	A	B	C	D	E	F	G	H
1	$2\frac{1}{16}$	$\frac{1}{4}$	0.00	$\frac{1}{4}$	$1\frac{5}{8}$	$1\frac{1}{4}$	2	1
2	$2\frac{3}{8}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{5}{16}$	$1\frac{5}{8}$	$1\frac{1}{4}$	2	1
3	$2\frac{5}{8}$	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{3}{8}$	$1\frac{5}{8}$	$1\frac{1}{4}$	2	1
4	$3\frac{3}{8}$	$1\frac{1}{4}$	$\frac{3}{4}$	$\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{1}{4}$	2	1
5	5	2	$1\frac{1}{4}$	$\frac{5}{8}$	$2\frac{1}{2}$	$1\frac{1}{16}$	3	2

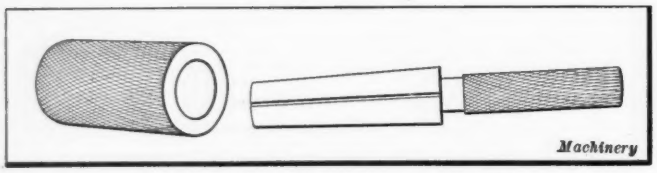


Fig. 30. Reference Taper Plug and Ring Gage

the taper. The limits of tolerance allowed on a taper fit are dependent on the degree of taper on the members, the methods used in holding the parts, and their relative positions. The limits for a taper fit are seldom less than 0.010 inch, longitudinal dimension, and vary as much as ⅛ inch on slight tapers.

Reference Taper Plug and Ring Gages

The gages used for inspecting taper shafts or holes are usually of a simple type, the test being made largely by applying Prussian blue to either the plug or the ring; especially is this necessary when testing the degree of taper. Fig. 30 shows what is known as a standard or reference taper plug and ring gage. The standard plug, as a rule, is provided with two or more shallow grooves to catch dust and dirt. The ring is also made with grooves, in some cases. When a taper plug is to be made for a standard taper, such as the Brown & Sharpe, Morse, Jarno, etc., the plug is made to the exact length specified, and the largest and smallest diameters on the plug are checked up within limits very close to those given for the different numbers of tapers. The same remarks, of course, apply to the ring. When a plug is to be made for other than what is known as the standard taper, the size of the large end and the amount of taper are the only two governing points.

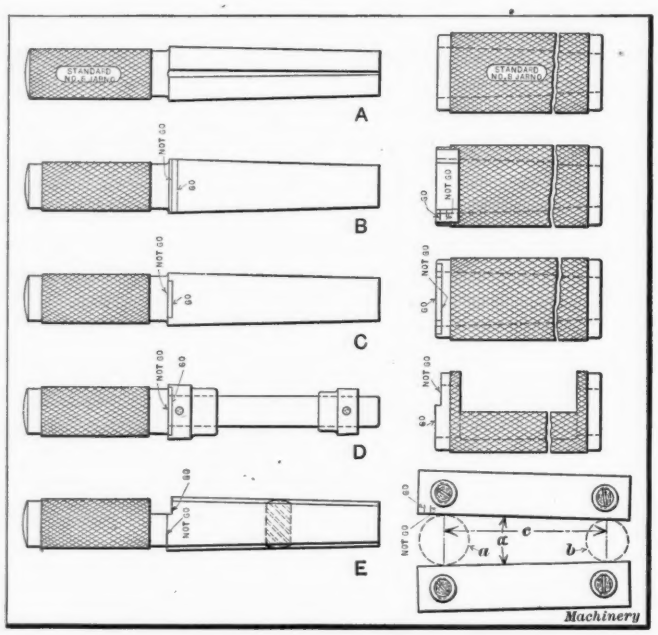


Fig. 31. Different Types of Taper Plug and Ring Gages

Setting Limits on Taper Gages

As has been previously mentioned, the two chief points to consider in securing a taper fit between two parts is the fit of the taper and the relative longitudinal positions of the parts. In most cases the largest diameter is taken as the standard size, but there are, of course, exceptions to this rule, the locomotive standard taper of 1/16 inch to the foot being a case in point. For average machine work, however, the large end of the taper is the point worked from, and consequently is the end of the gage on which the tolerance is given.

As it is seldom necessary to have a taper finish at a shoulder on average machine work, the tolerance permitted between two parts is, as a rule, not held to very close limits. There are cases, however, when the longitudinal position of one part on another must be held to close limits, and when this is so great care should be taken in setting the limits of tolerance. Knowing that it is possible to work to limits of ± 0.001 inch on cylindrical work, we will assume that this is also possible on taper work. Knowing also the tolerance on the longitudinal distance, we can obtain the distance which governs the positions of the "Go" and "Not Go" points for the various tapers per foot from Table VI. This table forms a basis for the location of the limit points. For example, assume that the taper on a shaft and hole which must go together is ¾ inch to the foot, and that these two parts must be made on a strictly interchangeable basis in large quantities. Assume also that the relative longitudinal position of the two parts is not highly important. The question to be settled is the distance between the "Go" and "Not Go" points on the male and female gages, respectively.

In order to provide as wide a limit as practicable, we will assume that the maximum tolerance on the hole and shaft, respectively, is 0.001 inch. In other words, assuming that the nominal size is 1.500, the largest hole would be 1.501 inch, and the largest diameter on the smallest shaft 1.499 inch. This gives an allowance between the diameters of the largest hole and smallest shaft of 0.002 inch. Hence it is necessary to know what longitudinal tolerance this represents in order to fix the limits on the male and female gages. Referring to Table VI, it will be noted that for a difference of 0.001 inch in diameter the length of the taper is 0.016 inch; hence for a difference of 0.002 inch in diameter the length of the taper is 0.032 inch. This amount is, therefore, the distance between the limit points on the male and female gages. When the taper is slight, say 0.250 inch to the foot, the length of the taper for a difference of 0.001 inch in diameter holds good only when the parts are put together without pressure.

Reference to Fig. 31, which shows various types of limit taper plug and ring gages, will show how the limit for longitudinal position is set. In the case shown at *B* the plug has two lines on it, the lower one of which is the "Go" and the other the "Not Go" position. The ring is cut away, as illustrated, and also has two lines on it, the lower one being the "Not Go" and the other the "Go" position. In setting the limits on the plug and ring gages, respectively, the "Go" position on the plug should correspond exactly with the "Not Go" position on the ring. In other words, when the ring is placed over the taper plug, the "Not Go" line on the ring should coincide with the "Go" line on the plug, and the "Go" line on the ring should coincide with the "Not Go" line on the plug. The distance between these two lines is the longitudinal tolerance. Of course, it is evident that the mean dimension on both the ring and the plug would be exactly the same size.

The kind of fit is governed by the amount of taper given to the part. For instance, on taper pins which will not work loose, the amount of taper varies from 1/16 to 1/4 inch to the foot. For sockets which are required to drive cutting tools, the tapers vary from 0.500 to 0.630 inch to the foot. For locomotive frame bolts, the taper is generally 1/16 inch to the foot. For arbors which carry shell reamers, etc., the taper is ⅛ inch to the foot. For general automobile work, the accepted taper is 1½ inch to

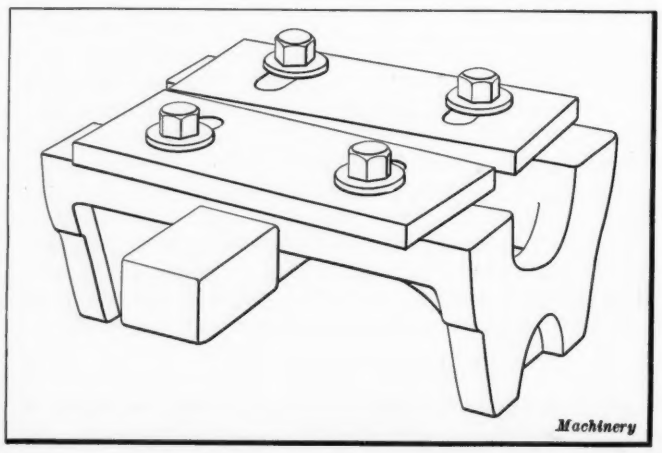


Fig. 32. Adjustable Taper Gage manufactured by Taft-Peirce Mfg. Co. incorporating Principle illustrated at E in Fig. 31

the foot. When the longitudinal movement of two parts that go together is not to be greater than 0.010 inch, a taper not less than 1½ inch to the foot is necessary, whereas if a longitudinal distance has a tolerance of 1/16 inch, a taper as small as ½ inch to the foot would be satisfactory, when the longitudinal position is the only factor that need be considered.

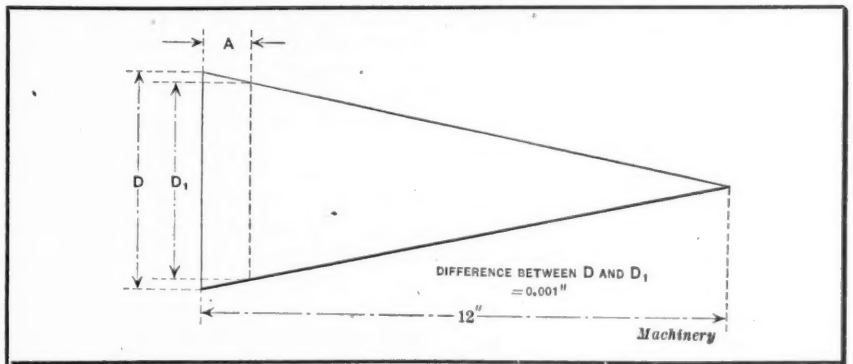
Types of Taper Plug and Ring Gages

The taper plug and ring gage shown at *A* in Fig. 31, as previously mentioned, is used only for reference purposes. *B* shows a type of taper plug and ring gage in which the limit is indicated by two lines. Another type of taper plug and ring gage is shown at *C*. Here instead of having the limit lines on the plug and ring, the two members are milled down as shown, the distance between the two milled cuts being the amount of tolerance on the work.

Another type of limit plug and ring gage is shown at *D*. In this case the plug consists of a handle to which two bushings are attached, which are ground to the correct taper. With this type of plug, it is a comparatively simple matter to get a correctly machined taper hole without the use of Prussian blue or other fitting pastes. The taper in the hole can be easily tested by the wabble of the plug, as it rests in the hole at two points only, instead of its entire length. A similar idea is carried out on the ring, which is cut away and relieved in the center as illustrated.

In using plug gages of the type illustrated at *B* and *C*, difficulty is sometimes experienced, especially when the taper is slight, in getting the plug stuck in the hole. One way of eliminating this is to make the plug as shown at *D*, but probably a more satisfactory way is to make it as shown at *E*. Here the plug is slabbed down on both sides, which allows free passage of the air; this will be found especially advantageous in gaging blind holes. The only disadvantage of this plug is the difficulty of lapping it accurately. At the right-hand side of the illustration at *E* is shown a method of using two straightedges for testing a taper. This type of gage is generally used on the bench, being mounted on a stand, and is especially useful for originating tapers. In connection with two hardened and ground rolls, as shown by the dotted line, these tapered straightedges can be set very accurately to any degree of taper desired and used as a standard, if a standard plug gage does not happen to be available.

TABLE VI. LENGTHS OF STANDARD TAPERS CORRESPONDING TO DIFFERENCE OF 0.001 INCH IN DIAMETER



Taper per Foot	A in Inches	Taper per Foot	A in Inches
0.0625 (locomotive work)	0.1920	0.6020 (Morse s't'd.)	0.0199
0.1250 (shell reamer arbors)	0.0960	0.6210 (American s't'd.)	0.0193
0.1875	0.0640	0.6230	0.0192
0.2500 (standard taper pins)	0.0480	0.6250 (Morse s't'd.)	0.0192
0.3750	0.0320	0.6260 (Morse s't'd.)	0.0191
0.5000 (Brown & Sharpe s't'd.)	0.0240	0.6300 (Morse s't'd.)	0.0190
0.5161 (Brown & Sharpe s't'd.)	0.0232	0.7500	0.0160
0.5430 (American s't'd.)	0.0229	1.0000	0.0120
0.5910 (American s't'd.)	0.0203	1.1250	0.0106
0.5920 (American s't'd.)	0.0200	1.2500	0.0096
0.6000 (Morse & Jarno s't'd.)	0.0200	1.5000 S. A. E. s't'd.	0.0080

Machinery

Measuring Tapers Accurately

When great accuracy is required in the measurement of tapers, the type of gage shown to the right of the illustration at *E* in Fig. 31 can be employed. This gage is made on the disk principle of measurement. It will be seen that if two disks of unequal diameters are held in contact or a certain distance apart, lines drawn tangent to their peripheries will represent an angle or taper, the degree of which depends on the relative diameters of the disks and the distance they are placed apart. Referring to *E* in Fig. 31, we will assume that it is necessary to set the gage to a taper of ¾ inch to the foot, and that the disk *a* is 1.5 inch and *b* 1.25 inch. It is desired to find the distance *c*, or the center distance between the two disks.

Rule:—Divide the taper per foot by 24 and find the angle corresponding to the quotient in a table of tangents; then find the sine corresponding to this angle, and divide the difference between the disk diameters by twice the sine. For example, let a = taper per foot; a = diameter of large disk; b = diameter of small disk; and c = the required center distance. Then $\frac{0.75}{24} = 0.03125$, which is the tangent of 1 degree, 47.4 minutes. Sin 1 degree, 47.4 minutes = 0.03123; 1.50 — 1.25 = 0.25 inch, $\frac{0.25}{2 \times 0.03123} = 4.002$ inch = center distance c.

A practical type of taper gage which incorporates the principle illustrated at *E* in Fig. 31, is shown in Fig. 32. This gage is made up of two adjustable straightedges mounted on a cast-iron body having a convenient handle on one side by which the gage may be held or clamped when in use. The

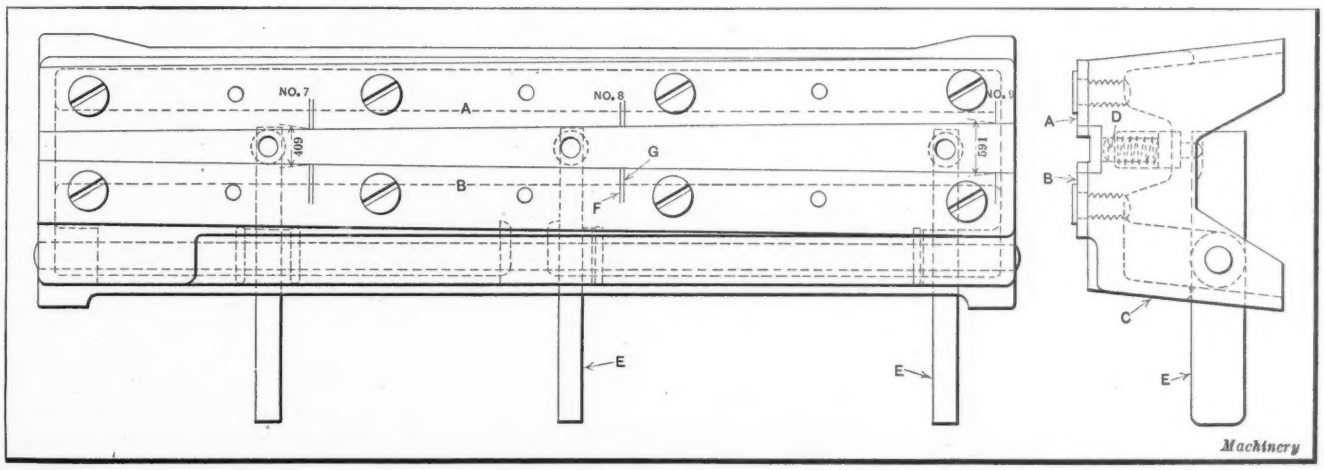


Fig. 33. Gage for testing Standard Taper Pins

straightedges are made of tool steel, hardened, ground and lapped, and are adjusted either to a standard taper gage or by means of disks, as previously mentioned.

Taper Pin Gage

A standard gage for testing taper pins is shown in Fig. 33. This gage is made so that it tests Nos. 7, 8 and 9 taper pins. It consists of two straightedges *A* and *B* fastened to a cast-iron base *C*. Located close to the largest diameter of each size of pin is a spring plunger *D* which is operated by the individual handles *E*. Lines *F* and *G* for each number indicate the minimum and maximum sizes at the large end of the pins. In being tested, the pins are slid along the slot until they bear against the sides of the straightedge. If the large end passes the limit lines, they are rejected.

This subject will be continued in the November number of MACHINERY, taking up templet gages, flush pin gages, height gages, and indicating gages of the multiple lever and dial types.

* * *

WORKING HOURS OF BULLARD MACHINE TOOL CO.

An article appeared in the June number on the Bullard "Maxi-pay" plan and twenty-four-hour, three-shift working day, which called forth an inquiry from H. Bollinckx, formerly of Brussels, Belgium, but now in Switzerland, waiting for the eviction of the German invaders to resume his engineering activities in Brussels. Mr. Bollinckx asked the following questions, which have been arranged in order with the answers kindly furnished by the Bullard Machine Tool Co.

1. At what time does each group of workmen begin work?
A.—The three shifts report at 7 A. M., 3 P. M., and 11 P. M.

2. What are the hours of rest during the eight hours of employment?
A.—Assemblers, erectors, bench hands and others are allowed fifteen minutes for lunch on two shifts only—from 10:45 to 11 on shift No. 1, reporting at 7 A. M., and from 7 to 7:15 on shift No. 2, reporting at 3 P. M. The men working under this arrangement make up eight hours by reporting fifteen minutes earlier than the machine operators, who eat their lunch between cuts. We employ machine operators only on the 11 P. M. shift. Therefore, no time out for lunch is necessary for No. 3 shift.

3. Does each group enter some time before the other quits work?
A.—Each shift reports in time to start when the other leaves.

4. Does each group or shift of workmen have its own foremen and sub-foremen?
A.—Yes; there are foremen and sub-foremen for each shift.

5. Is the pay for the night workers higher than for the day workers?
A.—No; we do not necessarily pay the night workers more than those working days.

6. Is it always the same group that works during the night?
A.—We have been working the same men at night, but the shifts should alternate.

7. How is the work handled which must be continued by a worker in the following shift?
A.—The foremen of each group report early and work overtime if necessary to explain work that must be finished by men in the following shifts.

* * *

Much attention has been given to the perfection of platinum substitutes for use in chemical work. Although several alloys are employed for certain purposes in which platinum was formerly used, it does not appear that any successful substitute has been found for platinum for the dishes and crucibles used in analytical work. These dishes must of necessity be such that they are not affected by the reagent used. Recent experiments conducted by Prof. Parr have resulted in the development of an alloy which is resistant to nitric acid. The alloy was conceived with the idea of combining elements of positive and negative electric properties in such a manner that the alloy would have a zero electric potential. The analysis of one of the alloys made during these experiments which satisfied the conditions required is as follows: Copper, 6.42; manganese, 0.98; silicon, 1.04; tungsten, 2.13; nickel, 60.65; aluminum, 1.09; iron, 0.76; chromium, 21.07; molybdenum, 4.67. Total, 98.81.—*Mineral Resources of the United States, 1915—Part I.*

CHOOSING A TRADE

BY F. B. JACOBS*

The young man whose parents can afford to send him to college with the object of fitting him for a profession is indeed fortunate. Not everyone, however, can afford to spend from $2000 to $10,000 in fitting their sons for life's struggle in the business world, and, on the other hand, many young men would rather not spend four years of valuable time in acquiring theory. Thus when the average boy leaves high school, he begins to think seriously of the problem of making a success of life. He joins the vast army of those who, because they do not possess capital, are required to exchange their labor, either mental or manual, for the dollars of their more fortunate brethren. Honest toil, no matter how menial, should not be disparaged, but when the boy chooses for himself, does he always choose wisely? Does he select a trade or calling that offers him chances for something better than unremitting toil year in and year out until he is thrown in the discard in old age?

Boys have their hobbies between the ages of twelve and sixteen, and these innocent pastimes often exert a powerful influence as regards their life work. As in illustration, how common it is to see a boy enthused over electricity. What a vast amount of time he spends in conducting experiments and poring over technical literature on the subject! This is all very well, as it keeps him out of mischief, but when he seriously considers becoming an electrician, why not point out to him that it is an utter impossibility to climb to the top of the ladder in this particular field without a college degree as an electrical engineer? The best he can attain is a job as a lineman at $3.50 a day, and mighty hard work at that.

As another illustration of energy that is often misplaced, look at the number of boys infected with the wireless telegraphy bacillus. They will barter almost anything for the materials with which to equip a receiving and sending apparatus, and it can be said with due credit to many of them that they actually succeed in sending and sometimes in receiving messages with a degree of proficiency that has more than once caused the federal authorities not a little concern. While wireless telegraphy is no doubt interesting, with a fair chance for a little melodrama thrown in once in awhile, it cannot truthfully be classed among the well paid trades. The boy becomes a competent operator in time, and there he stops. To be sure, the wireless operator has a comparatively easy time, as the amount of actual labor he does is almost nil. I remember one wireless operator, a young man of twenty-one or thereabout, with whom I became acquainted on one of the boats plying between Savannah and northern points. He confided to me that his salary was low, somewhat less than $100 a month, but he pointed with pride to the fact that he did not have to work hard. Anyone could see that, as his chief occupation seemed to be playing solitaire while he smoked an exceedingly strong cob pipe with a nonchalant air. No one can be blamed for choosing a calling whereby he earns a living with little physical exertion, but why settle on something that will never net more than $100 a month?

Many boys who are inclined to be fastidious choose callings that enable them to wear nice clothes and keep their hands clean. Drawing soda water and measuring ribbon are all very well in themselves, but the young man who spends the best years of his life at some simple work that will never net over $60 per month at best will bitterly regret his choice in after years. The desire to wear good clothes, which in truth is the outward appearance of prosperity, has led many a youth to accept a comparatively poorly paid position in preference to choosing a well paid trade, and only in later years, when precious opportunities are factors of the past, does he realize his mistake.

As a practical illustration of this, the following incident, which happened in a busy New England city of 20,000 inhabitants, may be of interest. The person in question, a young man of twenty-one, had just finished his apprenticeship as a stone mason. He learned the trade of his father, who had a well established business, and as the son was a skilled workman, his father had decided to take him into partnership.

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One day the young man, clad in overalls, happened to be walking down the main street of the city, where he passed a young lady with whom he was in love. They had already decided to marry, but preferred to wait until he was in a fair way to succeed in business. The next time he called on the object of his affections she told him that she could never marry a man who wore overalls, and further informed him by way of an ultimatum that he must do one of two things: seek more genteel employment or relinquish his claim on her. To make a long story short, he secured a clerkship at a moderate salary, married, raised a family in a state of what is often termed "genteel" poverty, and now in the afternoon of life his nose is still to the grindstone, so to speak; he must toil along until he dies in harness. It is needless to state that he would have shown better judgment in sticking to his trade and marrying a woman who did not object to overalls. As a contracting mason, he could easily have laid by a sufficient sum, say $15,000 to $25,000, upon which to retire. As it is, he is still sticking to his "genteel" position.

It is to be regretted that the average young man shuns well paid trades because of the actual labor involved. What is the matter with the younger generation; are they afraid to bend their backs or soil their hands? Ask the average high school boy of today how he would like to learn the molder's trade and he will look at you aghast. "Work in a dirty foundry?" he would probably reply. "I should say not." It is a common belief that the art of molding calls for a strong back and a weak head. What a fallacy! In this day of alloy steels and perfected foundry practice, there is hardly a trade that calls for more skill or actual technical knowledge, and the young man who fits himself to take charge of a modern steel foundry will eventually fill a well paid position, while his schoolmates who chose nice, clean, ordinary work will find themselves in the same class with the ex-stone mason referred to previously. I have in mind two young molders who some time ago decided to go into business for themselves. They leased a vacant building in one of the Middle Western cities and started a steel foundry. One looks after the foundry, while the other attends to the correspondence and sales end of the business. Today they are on the road to prosperity. I wonder if they would have been as successful if they had chosen to clerk in a dry goods store. Ten or fifteen years hence, when the average store clerk is complaining about the high cost of living, these men will be riding in their high-powered touring cars, and they will not have to mortgage their homes for the sake of this luxury either.

In considering trades in general it is doubtful if any offers more opportunities than the machinist's trade. This may sound like a sweeping statement, but a little thought will convince the most skeptical that my theory is well grounded. In speaking of a machinist, I do not refer to a screw machine, milling machine, grinder or lathe hand, as these men, at best, are only operators. I refer to the all-around machinist, who can prosecute machine work of all kinds from blueprints. It is to be regretted that workmen of this kind are getting scarcer as the years go by, owing chiefly to the fact that machine work is rapidly becoming specialized. Indeed, this specialization has even invaded the tool-room. In place of the all-around toolmaker of a decade ago, we have the tool planer hand, the tool milling machine hand, the tool lathe hand, the tool grinder hand, and so on. It is getting to a point where the actual toolmaker does little else than lay out and bore jigs. In that case some one is sure to inquire: "What is the use of becoming an all-around man?" It is a fact that modern shop practice has reached a point where all-around men are not needed on actual production work, but at the same time we must not overlook the fact that there will always be good opportunities for the man who understands all sides of the machinist's trade. Such a man can always find employment at experimental or repair work—two of the most interesting as well as the best paid branches of modern shop practice. Work of this kind develops initiative, because the individual is compelled to do his own thinking, and when a man has once learned the secret of thinking carefully and planning for the future, even if it is only for a few minutes or hours ahead, he has discovered the true secret of success.

As an all-around machinist, the individual finds steady employment at good wages, because the management realizes that his services are too valuable to dispense with, even in moderately dull times. In summing up evidence to substantiate the claim that the machinist's trade offers exceptional inducements to the average young man, we must not overlook the fact that it often serves as a stepping stone to better paying positions, among which might be mentioned mechanical drafting and salesmanship. Of course there is absolutely no comparison between these two callings, but I mention them because it is an undisputed fact that any number of machinists have succeeded in these two lines owing to their previous shop training. The machinist makes an excellent draftsman, provided he has a talent for drawing (and most machinists have), because he understands how various pieces can be designed so as to be produced economically. Machinist draftsmen do not design pieces that are impossible to mold, neither do they create monstrosities that are impossible to machine, because their practical experience has taught them to avoid these blunders. They succeed at drafting because they understand the practical side of the work from the ground up, whereas the purely theoretical man gropes along in the dark, to a certain extent at least. In considering the machinist as a salesman, it is understood, of course, that he should exercise his abilities in mechanical lines. One might be an excellent machinist, but this fact would not prove of any value should he try to sell shoes or clothing. Machine tools, shop accessories, small tools, or mill supplies are the lines wherein the machinist succeeds, because his practical knowledge, gained from actual experience, proves of untold value in setting forth the merits of his goods. Shop superintendents admire practical knowledge in salesmen who interview them, even if they do not always admit this to be a fact, and the man who can answer mechanical questions in an intelligent manner stands a far better show in obtaining a satisfactory hearing than the man who has acquired his knowledge, parrot like, from the sales manager, or from reading books. Actual salesmanship, or the art of influencing the purchasing agent to "come across" with an order, to use a common expression, can be developed to a high degree, but we must also consider the fact that selling methods have changed in the last fifteen years, owing to the fact that the purchasing of goods is also becoming a science in itself. The purchasing agent of today is as keen to ward off undue influence as the salesman is to exercise it; thus the time is rapidly approaching when goods will be sold strictly on their merits. Therefore it will be seen that the man who understands the practical application of mechanical principles should succeed at salesmanship, provided he has latent ability at selling and understands the goods he handles.

Thus the machinist's trade offers excellent opportunities for any young man who is compelled to work for a living. The art of working metals is one of the oldest and most interesting handicrafts known to man, and in a large manufacturing country like ours the opportunities for master workmen are practically unlimited. We are inclined to point with pride to the remarkable mechanical achievements of the last half century, yet in spite of all we have accomplished, the machine industry is yet in its infancy, and the young man who connects himself with the trade at the present time is sure to reap the harvest in later years, his success, of course, being governed by his individual application to the various problems that confront him.

* * *

The electric welding of iron and steel will be a feature exhibit of the New York Electrical Exposition that will be held in the Grand Central Palace, October 11 to 21. The exhibit is being arranged by the Arc Welding Machine Co. of New York City. All grades of welding will be done in iron and steel, including structural pieces, plates and castings. Two arcs will be in operation equipped with automatic control which prevents the metal from burning through drawing too long an arc. The length of the arc is automatically controlled so that even a comparatively unskilled worker cannot draw it beyond the point set.

SINE BAR APPLICATIONS*

DETAILS OF CONSTRUCTION AND METHODS OF OBTAINING ACCURATE ANGULAR WORK

BY DONALD BAKER†

THE method of setting up or laying out angular work of various kinds most familiar to the average mechanic is by means of some form of protractor; the accuracy of this method depends first upon the accuracy of the instrument used, and second upon the workman's ability to set it to the marked graduations. When the limits allowed upon the work are not greater than five to ten minutes, a good protractor will usually answer all purposes, but for finer work, such as the laying out or testing of accurate jigs, fixtures and gages, or the making of sheet metal templets for typewriter, adding machine parts, etc., for experimental purposes, or as masters from which to make tools and dies, an instrument known as the sine bar has come into limited use. Its use is limited, however, only because of a lack of familiarity with it by men who would find a ready application for it were they better acquainted with its convenience and adaptability. The fact that few workmen are able to use simple shop trigonometry also tends to prevent the common use of the sine bar.

This article will not deal with the principles of trigonometry, as a knowledge of it is unnecessary in using a sine bar for setting up a piece of work to a given angle. However, as a knowledge of the use of trigonometrical functions is of the utmost use to the toolmaker who wishes to advance himself, and as the process is, after all, very simple and easy to use, I cannot but recommend that all who read this article will take the few hours needed to obtain a working knowledge of the process. Tables of sines, tangents, etc., with directions for their use, may be found in any engineering handbook, and one of the best for the toolmakers' use is contained in MACHINERY'S HANDBOOK.

The sine bar in its simplest form is a plain bar of metal, having a disk of steel at each end. These disks are of equal diameter and their centers lie in a line that is parallel with the edges of the bar on which they are mounted. It is customary to clamp this bar to the face of an angle-plate as shown in Fig. 1,

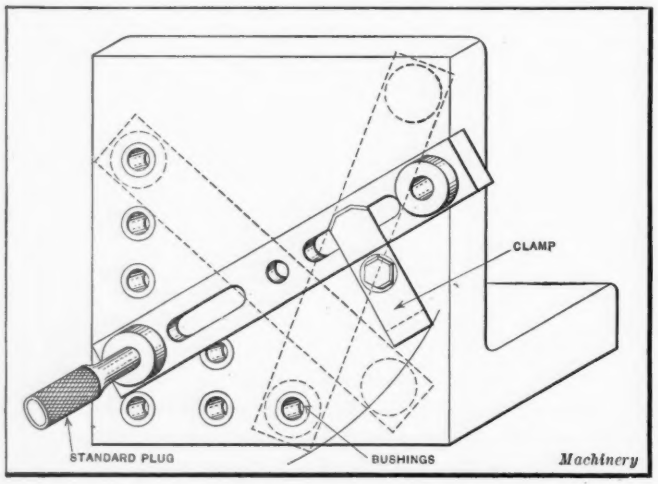

Fig. 1. Special Angle-plate with Sine Bar in Position

setting one of the steel disks above the other an amount corresponding to the sine of the angle desired, multiplied by the center distance between the disks. Let us assume that the bar shown in the illustration has the disks spaced five inches from center to center and that it is desired to set it up to an angle of 30 degrees from the horizontal. Referring to a table of sines, we find under the column 30 degrees, 0 minutes the figure 0.5000; multiplying this by 5 gives us 2.500, or 2½ inches, which is the height one disk must be set above the other. The setting is accomplished by the use of a height gage, size blocks, or other means which will give the required accuracy. When properly set, the sine bar is clamped fast to the angle-plate so that the work can be placed on top of it and likewise clamped in position. The work of laying out, drilling, grinding, or any other operation may now be carried on with the assurance that the angular setting is correct.

Construction of a Sine Bar

Fig. 2 shows a detail of a sine bar somewhat as described, but having a few improvements which have suggested them-

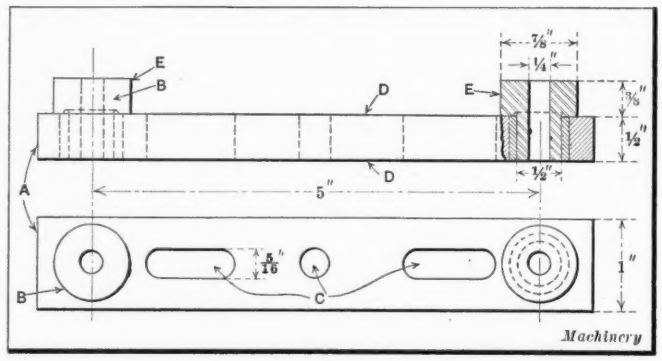

Fig. 2. Detail of Simple Sine Bar

selves to the writer in his experience with this type of instrument. The body of the sine bar *A* can be made of tool steel, hardened, or of machine steel, pack-hardened. I prefer the latter, as there is less likelihood of changes occurring due to hardening strains which sometimes affect the accuracy of a tool steel bar after it has been made. The two steel disks *B* (one at each end) have their centers exactly 5 inches apart, or 10 inches apart for a larger sine bar. Other lengths may be used, but the 5-inch bar has been found the most convenient for average small tool work. The figures 5 and 10, which represent the center distances of the disks, are most convenient to use in multiplying the figures taken from a table of sines. In the case of the 10-inch bar, no multiplying is required when using the regular table of sines, as it is only necessary to point off one decimal place to the right to obtain the required figure.

In making a bar of this kind, a piece of steel is first planed or milled for the body *A*, and two 11/16-inch holes are bored through it, one at each end approximately 5 inches between centers; then the holes *C* are drilled, no particular pains being taken with these, as they are only clearance holes, as will be explained later. The bar is now ready to harden, after which the two end holes must be lapped out just enough to remove the hardening scale and two soft steel plugs pressed into them. The surfaces *D* are next ground parallel with each other on a surface grinder. After grinding, the bar is strapped to the faceplate of an engine lathe while one of the soft steel plugs is bored out to ½ inch diameter, after which a half-inch standard plug is placed in the hole and a half-inch standard jig button is fastened to the soft plug at the other end. The button is then adjusted until its center comes central with the edges of the bar and is exactly 5 inches from the standard plug, this dimension being easily determined by measuring across the outside diameters or by means of a 4½-inch space bar placed between the plug and the button. The standard plug is now removed, and the bar carrying the jig button is again taken to the engine lathe and clamped to the faceplate while the button is indicated until it runs perfectly true. It is then removed and a hole drilled and bored to half-inch diameter in the usual manner. After the bar is removed from the lathe, two half-inch standard plugs or their equivalent are placed in the two holes and the bar tested for accuracy. If there has been an error by any chance, it is an easy matter to remove one of the soft plugs and replace it with another,

* For other articles on angle measurement, see "Precision Method of Measuring Angles," October, 1914; "Disk and Square Method of Determining Angular Settings," October, 1913; and "Use of the Sine Bar for Measuring Angles," January, 1912.

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CONSTANTS FOR 5-INCH SINE BAR

M	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°
0	0.00000	0.08725	0.17450	0.26170	0.34880	0.43580	0.52265	0.60935	0.69585	0.78215	0.86825	0.95405	1.0395	1.1247	1.2096
1	.00145	.08870	.17595	.26315	.35025	.43725	.52410	.61080	.69730	.78360	.86965	.95545	.0410	.1261	.2110
2	.00290	.09015	.17740	.26460	.35170	.43870	.52555	.61225	.69875	.78505	.87110	.95690	.0424	.1276	.2124
3	.00435	.09160	.17885	.26605	.35315	.44015	.52700	.61370	.70020	.78650	.87255	.95835	.0438	.1290	.2138
4	.00580	.09310	.18030	.26750	.35460	.44155	.52845	.61510	.70165	.78790	.87395	.95975	.0452	.1304	.2152
5	0.00725	0.09455	0.18175	0.26895	0.35605	0.44300	0.52985	0.61655	0.70305	0.78935	0.87540	0.96120	1.0466	1.1318	1.2166
6	.00875	.09600	.18320	.27040	.35750	.44445	.53130	.61800	.70450	.79080	.87685	.96260	.0481	.1332	.2181
7	.01020	.09745	.18465	.27185	.35895	.44590	.53275	.61945	.70595	.79225	.87825	.96405	.0495	.1346	.2195
8	.01165	.09890	.18615	.27330	.36040	.44735	.53420	.62090	.70740	.79365	.87970	.96545	.0509	.1361	.2209
9	.01310	.10035	.18760	.27475	.36185	.44880	.53565	.62235	.70885	.79510	.88115	.96690	.0523	.1375	.2223
10	0.01455	0.10180	0.18905	0.27620	0.36330	0.45025	0.53710	0.62380	0.71025	0.79655	0.88255	0.96830	1.0538	1.1389	1.2237
11	.01600	.10325	.19050	.27765	.36475	.45170	.53855	.62520	.71170	.79795	.88400	.96975	.0552	.1403	.2251
12	.01745	.10470	.19195	.27910	.36620	.45315	.54000	.62665	.71315	.79940	.88540	.97115	.0566	.1417	.2265
13	.01890	.10615	.19340	.28055	.36765	.45460	.54145	.62810	.71460	.80085	.88685	.97260	.0580	.1431	.2279
14	.02035	.10760	.19485	.28200	.36910	.45605	.54290	.62955	.71600	.80230	.88830	.97405	.0594	.1446	.2293
15	0.02180	0.10905	0.19630	0.28345	0.37055	0.45750	0.54435	0.63100	0.71745	0.80370	0.88970	0.97545	1.0609	1.1460	1.2307
16	.02325	.11055	.19775	.28490	.37200	.45895	.54580	.63245	.71890	.80515	.89115	.97690	.0623	.1474	.2322
17	.02475	.11200	.19920	.28635	.37345	.46040	.54725	.63390	.72035	.80660	.89260	.97830	.0637	.1488	.2336
18	.02620	.11345	.20065	.28780	.37490	.46185	.54865	.63530	.72180	.80800	.89400	.97975	.0651	.1502	.2350
19	.02765	.11490	.20210	.28925	.37635	.46330	.55010	.63675	.72320	.80945	.89545	.98115	.0665	.1516	.2364
20	0.02910	0.11635	0.20355	0.29070	0.37780	0.46475	0.55155	0.63820	0.72465	0.81090	0.89685	0.98260	1.0680	1.1531	1.2378
21	.03055	.11780	.20500	.29220	.37925	.46620	.55300	.63965	.72610	.81230	.89830	.98400	.0694	.1545	.2392
22	.03200	.11925	.20645	.29365	.38070	.46765	.55445	.64110	.72755	.81375	.89975	.98545	.0708	.1559	.2406
23	.03345	.12070	.20795	.29510	.38215	.46910	.55590	.64255	.72900	.81520	.90115	.98685	.0722	.1573	.2420
24	.03490	.12215	.20940	.29655	.38360	.47055	.55735	.64400	.73040	.81665	.90260	.98830	.0737	.1587	.2434
25	0.03635	0.12360	0.21085	0.29800	0.38505	0.47200	0.55880	0.64540	0.73185	0.81805	0.90405	0.98970	1.0751	1.1601	1.2448
26	.03780	.12505	.21230	.29945	.38650	.47345	.56025	.64685	.73330	.81950	.90545	.99115	.0765	.1615	.2462
27	.03925	.12650	.21375	.30090	.38795	.47490	.56170	.64830	.73475	.82095	.90690	.99255	.0779	.1630	.2477
28	.04070	.12800	.21520	.30235	.38940	.47635	.56315	.64975	.73615	.82235	.90830	.99400	.0793	.1644	.2491
29	.04220	.12945	.21665	.30380	.39085	.47780	.56455	.65120	.73760	.82380	.90975	.99540	.0808	.1658	.2505
30	0.04365	0.13090	0.21810	0.30525	0.39230	0.47925	0.56600	0.65265	0.73905	0.82525	0.91120	0.99685	1.0822	1.1672	1.2519
31	.04510	.13235	.21955	.30670	.39375	.48070	.56745	.65405	.74050	.82665	.91260	.99825	.0836	.1686	.2533
32	.04655	.13380	.22100	.30815	.39520	.48210	.56890	.65550	.74190	.82810	.91405	.99970	.0850	.1700	.2547
33	.04800	.13525	.22245	.30960	.39665	.48355	.57035	.65695	.74335	.82955	.91545	1.0011	.0864	.1714	.2561
34	.04945	.13670	.22390	.31105	.39810	.48500	.57180	.65840	.74480	.83100	.91690	.0016	.0879	.1729	.2575
35	0.05090	0.13815	0.22535	0.31250	0.39955	0.48645	0.57325	0.65985	0.74625	0.83240	0.91835	1.0039	1.0893	1.1743	1.2589
36	.05235	.13960	.22680	.31395	.40100	.48790	.57470	.66130	.74770	.83385	.91975	.0054	.0907	.1757	.2603
37	.05380	.14105	.22825	.31540	.40245	.48935	.57615	.66270	.74910	.83530	.92120	.0068	.0921	.1771	.2617
38	.05525	.14250	.22970	.31685	.40390	.49080	.57760	.66415	.75055	.83670	.92260	.0082	.0935	.1785	.2631
39	.05670	.14395	.23115	.31830	.40535	.49225	.57900	.66560	.75200	.83815	.92405	.0096	.0949	.1799	.2645
40	0.05820	0.14540	0.23265	0.31975	0.40680	0.49370	0.58045	0.66705	0.75345	0.83960	0.92545	1.0110	1.0964	1.1813	1.2660
41	.05965	.14690	.23410	.32120	.40825	.49515	.58190	.66850	.75485	.84100	.92690	.0125	.0978	.1828	.2674
42	.06110	.14835	.23555	.32265	.40970	.49660	.58335	.66995	.75630	.84245	.92835	.0139	.0992	.1842	.2688
43	.06255	.14980	.23700	.32410	.41115	.49805	.58480	.67135	.75775	.84390	.92975	.0153	.1006	.1856	.2702
44	.06400	.15125	.23845	.32555	.41260	.49950	.58625	.67280	.75920	.84530	.93120	.0168	.1020	.1870	.2716
45	0.06545	0.15270	0.23990	0.32700	0.41405	0.50095	0.58770	0.67425	0.76060	0.84675	0.93260	1.0182	1.1035	1.1884	1.2730
46	.06690	.15415	.24135	.32845	.41550	.50240	.58915	.67570	.76205	.84820	.93405	.0196	.1049	.1898	.2744
47	.06835	.15560	.24280	.32990	.41695	.50385	.59060	.67715	.76350	.84960	.93550	.0210	.1063	.1912	.2758
48	.06980	.15705	.24425	.33135	.41840	.50530	.59200	.67860	.76495	.85105	.93690	.0225	.1077	.1926	.2772
49	.07125	.15850	.24570	.33280	.41985	.50675	.59345	.68000	.76635	.85250	.93835	.0239	.1091	.1941	.2786
50	0.07270	0.15995	0.24715	0.33425	0.42130	0.50820	0.59490	0.68145	0.76780	0.85390	0.93975	1.0253	1.1106	1.1955	1.2800
51	.07415	.16140	.24860	.33570	.42275	.50960	.59635	.68290	.76925	.85535	.94120	.0267	.1120	.1969	.2814
52	.07565	.16285	.25005	.33715	.42420	.51105	.59780	.68435	.77070	.85680	.94260	.0281	.1134	.1983	.2828
53	.07710	.16430	.25150	.33865	.42565	.51250	.59925	.68580	.77210	.85820	.94405	.0296	.1148	.1997	.2842
54	.07855	.16580	.25295	.34010	.42710	.51395	.60070	.68720	.77355	.85965	.94550	.0310	.1162	.2011	.2856
55	0.08000	0.16725	0.25440	0.34155	0.42855	0.51540	0.60215	0.68865	0.77500	0.86110	0.94690	1.0324	1.1176	1.2025	1.2870
56	.08145	.16870	.25585	.34300	.43000	.51685	.60355	.69010	.77645	.86250	.94835	.0338	.1191	.2039	.2884
57	.08290	.17015	.25730	.34445	.43145	.51830	.60500	.69155	.77785	.86395	.94975	.0353	.1205	.2054	.2899
58	.08435	.17160	.25875	.34590	.43290	.51975	.60645	.69300	.77930	.86540	.95120	.0367	.1219	.2068	.2913
59	.08580	.17305	.26028	.34735	.43435	.52120	.60790	.69445	.78075	.86680	.95260	.0381	.1233	.2082	.2927
60	0.08725	0.17450	0.26170	0.34880	0.43580	0.52265	0.60935	0.69585	0.78215	0.86825	0.95405	1.0395	1.1247	1.2096	1.2941

M	15°	16°	17°	18°	19°	20°	21°	22°	23°	24°	25°	26°	27°	28°	29°
0	1.2941	1.3782	1.4618	1.5451	1.6278	1.7101	1.7918	1.8730	1.9536	2.0337	2.1131	2.1918	2.2699	2.3473	2.4240
1	.2955	.3796	.4632	.5464	.6292	.7114	.7932	.8744	.9550	.0350	.1144	.1931	.2712	.3486	.4253
2	.2969	.3810	.4646	.5478	.6306	.7128	.7945	.8757	.9563	.0363	.1157	.1944	.2725	.3499	.4266
3	.2983	.3824	.4660	.5492	.6319	.7142	.7959	.8771	.9576	.0376	.1170	.1958	.2738	.3512	.4278
4	.2997	.3838	.4674	.5506	.6333	.7155	.7972	.8784	.9590	.0390	.1183	.1971	.2751	.3525	.4291
5	1.3011	1.3852	1.4688	1.5520	1.6347	1.7169	1.7986	1.8797	1.9603	2.0403	2.1197	2.1984	2.2764	2.3538	2.4304
6	.3025	.3865	.4702	.5534	.6361	.7183	.8000	.8811	.9617	.0416	.1210	.1997	.2777	.3550	.4317
7	.3039	.3879	.4716	.5547	.6374	.7196	.8013	.8824	.9630	.0430	.1223	.2010	.2790	.3563	.4329
8	.3053	.3893	.4730	.5561	.6388	.7210	.8027	.8838	.9643	.0443	.1236	.2023	.2803	.3576	.4342
9	.3067	.3907	.4743	.5575	.6402	.7224	.8040	.8851	.9657	.0456	.1249	.2036	.2816	.3589	.4355
10	1.3081	1.3921	1.4757	1.5589	1.6416	1.7237	1.8054	1.8865	1.9670	2.0469	2.1262	2.2049	2.2829	2.3602	2.4367
11	.3095	.3935	.4771	.5603	.6429	.7251	.8067	.8878	.9683	.0483	.1276	.2062	.2842	.3614	.4380
12	.3109	.3949	.4785	.5616	.6443	.7265	.8081	.8892	.9697	.0496	.1289	.2075	.2855	.3627	.4393
13	.3123	.3963	.4799	.5630	.6457	.7292	.8108	.8919	.9724	.0522	.1302	.2088	.2868	.3640	.4405
14	.3137	.3977	.4813	.5644	.6471	.7242	.8108	.8919	.9724	.0522	.1315	.2101	.2881	.3653	.4418
15	1.3151	1.3991	1.4827	1.5658	1.6484	1.7306	1.8122	1.8932	1.9737	2.0536	2.1328	2.2114	2.2893	2.3666	2.4431
16	.3165	.4005	.4841	.5672	.6498	.7319	.8135	.8946	.9750	.0549	.1341	.2127	.2906	.3679	.4444
17	.3179	.4019	.4855	.5686	.6512	.7333	.8149	.8959	.9764	.0562	.1354	.2140	.2919	.3691	.4456
18	.3193	.4033	.4868	.5699	.6525	.7347	.8162	.8973	.9777	.0575	.1368	.2153	.2932	.3704	.4469
19	.3207	.4047	.4882	.5713	.6539	.7360	.8176	.8986	.9790	.0589	.1381	.2166	.2945	.3717	.4482
20	1.3221	1.4061	1.4896	1.5727	1.6553	1.7374	1.8189	1.8999	1.9804	2.0602	2.1394	2.2179	2.2958	2.3730	2.4494
21	.3235	.4075	.4910	.5741	.6567	.7387	.8203	.9013	.9817	.0615	.1407	.2192	.2971	.3743	.4507
22	.3250	.4089	.4924	.5755	.6580	.7401	.8217	.9026	.9830	.0628	.1420	.2205	.2984	.3755	.4520
23	.3264	.4103	.4938	.5768	.6594	.7415	.8230	.9040	.9844	.0642	.1433	.2218	.2997	.3768	.4532
24	.3278	.4117	.4952	.5782	.6608	.7428	.8244	.9053	.9857	.0655	.1447	.2232	.3010	.3781	.4545
25	1.3292	1.4131	1.4966	1.5796	1.6622	1.7442	1.8257	1.9067	1.9870	2.0668	2.1460	2.2245	2.3023	2.3794	2.4558
26	.3306	.4145	.4980	.5810	.6635	.7456	.8271	.9080	.9884	.0681	.1473	.2258	.3036	.3807	.4570
27	.3320	.4159	.4993	.5824	.6649	.7469	.8284	.9094	.9897	.0695	.1486	.2271	.3048	.3819	.4583
28	.3334	.4173	.5007	.5837	.6663	.7483	.8298	.9107	.9911	.0708	.1499	.2284	.3061	.3832	.4596
29	.3348	.4187	.5021	.5851	.6676	.7496	.8311	.9120	.9924	.0721	.1512	.2297	.3074	.3845	.4608
30	1.3362	1.4201	1.5035	1.5865	1.6690	1.7510	1.8325	1.9134	1.9937	2.0734	2.1525	2.2310	2.3087	2.3858	2.4621
31	.3376	.4214	.5049	.5879	.6704	.7524	.8338	.9147	.9951	.0748	.1538	.2323	.3100	.3870	.4634
32	.3390	.4228	.5063	.5893	.6718	.7537	.8352	.9161	.9964	.0761	.1552	.2336	.3113	.3883	.4646
33	.3404	.4242	.5077	.5906	.6731	.7551	.8365	.9174	.9977	.0774	.1565	.2349	.3126	.3896	.4659
34	.3418	.4256	.5091	.5920	.6745	.7565	.8379	.9188	.9991	.0787	.1578	.2362	.3139	.3909	.4672
35	1.3432	1.4270	1.5104	1.5934	1.6759	1.7578	1.8392	1.9201	2.0004	2.0801	2.1591	2.2375	2.3152	2.3922	2.4684
36	.3446	.4284	.5118	.5948	.6772	.7592	.8406	.9215	.0017	.0814	.1604	.2388	.3165	.3934	.4697
37	.3460	.4298	.5132	.5961	.6786	.7605	.8419	.9228	.0031	.0827	.1617	.2401	.3177	.3947	.4709
38	.3474	.4312	.5146	.5975	.6800	.7619	.8433	.9241	.0044	.0840	.1630	.2414	.3190	.3960	.4722
39	.3488	.4326	.5160	.5989	.6813	.7633	.8447	.9255	.0057	.0853	.1643	.2427	.3203	.3973	.4735
40	1.3502	1.4340	1.5174	1.6003	1.6827	1.7646	1.8460	1.9268	2.0070	2.0867	2.1656	2.2440	2.3216	2.3985	2.4747
41	.3516	.4354	.5188	.6017	.6841	.7660	.8474	.9282	.0084	.0880	.1670	.2453	.3229	.3998	.4760
42	.3530	.4368	.5201	.6030	.6855	.7673	.8487	.9295	.0097	.0893	.1683	.2466	.3242	.4011	.4773
43	.3544	.4382	.5215	.6044	.6868	.7687	.8501	.9308	.0110	.0906	.1696	.2479	.3255	.4024	.4785
44	.3558	.4396	.5229	.6058	.6882	.7701	.8514	.9322	.0124	.0920	.1709	.2492	.3268	.4036	.4798
45	1.3572	1.4410	1.5243	1.6072	1.6896	1.7714	1.8528	1.9335	2.0137	2.0933	2.1722	2.2505	2.3280	2.4049	2.4811
46	.3586	.4423	.5257	.6085	.6909	.7728	.8541	.9349	.0150	.0946	.1735	.2518	.3293	.4062	.4823
47	.3600	.4437	.5271	.6099	.6923	.7742	.8555	.9362	.0164	.0959	.1748	.2531	.3306	.4075	.4836
48	.3614	.4451	.5285	.6113	.6937	.7755	.8568	.9376	.0177	.0972	.1761	.2544	.3319	.4087	.4848
49	.3628	.4465	.5298	.6127	.6950	.7769	.8582	.9389	.0190	.0986	.1774	.2557	.3332	.4100	.4861
50	1.3642	1.4479	1.5312	1.6141	1.6964	1.7782	1.8595	1.9402	2.0204	2.0999	2.1787	2.2570	2.3345	2.4113	2.4874
51	.3656	.4493	.5326	.6154	.6978	.7796	.8609	.9416	.0217	.1012	.1801	.2583	.3358	.4126	.4886
52	.3670	.4507	.5340	.6168	.6991	.7809	.8622	.9429	.0230	.1025	.1814	.2596	.3371	.4138	.4899
53	.3684	.4521	.5354	.6182	.7005	.7823	.8636	.9443	.0244	.1038	.1827	.2609	.3383	.4151	.4912
54	.3698	.4535	.5368	.6196	.7019	.7837	.8649	.9456	.0257	.1052	.1840	.2621	.3396	.4164	.4924
55	1.3712	1.4549	1.5381	1.6209	1.7032	1.7850	1.8663	1.9469	2.0270	2.1065	2.1853	2.2634	2.3409	2.4177	2.4937
56	.3726	.4563	.5395	.6223	.7046	.7864	.8676	.9483	.0283	.1078	.1866	.2647	.3422	.4189	.4949
57	.3740	.4577	.5409	.6237	.7060	.7877	.8690	.9496	.0297	.1091	.1879	.2660	.3435	.4202	.4962
58	.3754	.4591	.5423	.6251	.7073	.7891	.8703	.9510	.0310	.1104	.1892	.2673	.3448	.4215	.4975
59	.3768	.4604	.5437	.6264	.7087	.7905	.8717	.9523	.0323	.1117	.1905	.2686	.3460	.4228	.4987
60	1.3782	1.4618	1.5451	1.6278	1.7101	1.7918	1.8730	1.9536	2.0337	2.1131	2.1918	2.2699	2.3473	2.4240	2.6000

Machinery

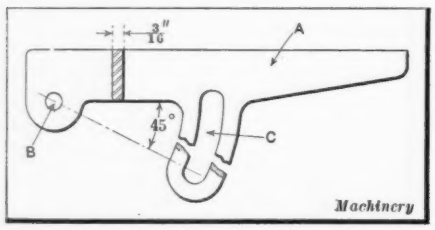

Fig. 3. Special Attachment for Use with Sine Bar shown in Fig. 2

after which the operations described can be repeated until the holes are absolutely correct.

Making the Disks

The disks used on the sine bar are made of tool steel, hardened and ground all over. These disks are made to the dimensions given in Fig. 2, roughing them out first on the lathe, allowing 0.010 inch on the outside for grinding and 0.002 inch on the inside for lapping. After the disks have been hardened, the center hole is lapped out to 0.250 inch and a short piece of drill rod is placed in the bench lathe chuck and ground until the button will just wring on by hand, in which position it can be ground on the outside with the assurance that all parts will run perfectly true with each other. In grinding the disks, about 0.0005 inch is left on the large diameter, this amount being afterward lapped off to make the button perfectly round and bring it to size. The buttons are next forced into the soft bushings at the ends of the sine bar, the bar fastened to an angle-plate with one edge up, and the buttons indicated until they are level; the bar is then ground on one edge in this position on a surface grinder. After this, the bar is removed and the ground edge is placed down on a magnetic chuck or the bed of the grinder while the other edge is being finished. At this point it might be well to give a word of caution to the inexperienced toolmaker; it is necessary to rough out all parts that are to be hardened, then harden and rough-grind, and lay them away for a period of six months or so before the final finishing, if the most accurate work is required. Unless this is done there is always a chance that the parts may change their shape in a short time sufficiently to render them more or less inaccurate, especially if tool steel is used in the construction.

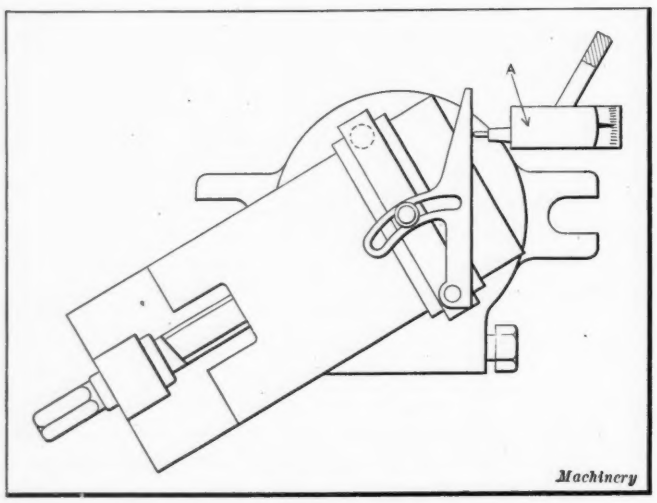

Fig. 4. Method of Setting a Milling Machine Vise by the Use of a Sine Bar

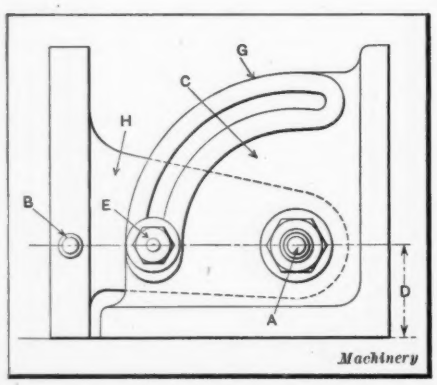

Fig. 5. Special Angular Fixture for Toolroom Use

Method of Using the Sine Bar

The attachment shown in Fig. 3 may be used in any place in which the regular bar can be used, but has the other features noted herewith. Screws may be placed through the slot and hole to clamp the attachment directly to a piece of work or to the angle-plate when it is desired to do so. In order to make settings more rapidly, I have prepared an angle-plate like that shown in Fig. 1. This plate has inserted in its face a number of hardened, ground and lapped bushings, the holes in which are fitted to a standard quarter-inch plug. In using this plate in connection with the sine bar, the bar is placed on the plate and the standard plug inserted through the button and into a bushing; then the bar is set approximately to the required angle and lightly clamped. The exact vertical height of the bushing in which the plug is placed being known, it is only necessary to make one measurement in setting the second button. The more common method without the use of the angle-plate described would be to place a height block under the lower button and adjust the second button to the correct height by means of a height or surface gage.

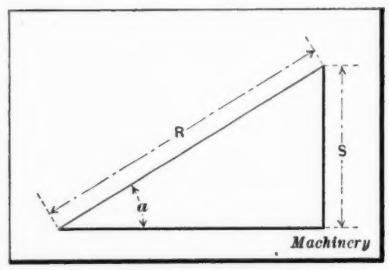

Fig. 6. Diagram showing Sine Bar Basic Principles

Another use for the sine bar having holes through the buttons is shown in Fig. 4. This is in the setting of a milling machine vise or piece of work on the milling machine table or elsewhere, where it would be inconvenient to indicate the buttons direct. This is accomplished by the use of the attachment shown in Fig. 3. This attachment is made from 3/16-inch B. & S. ground stock, machined to the form shown and hardened and ground on the edge *A*. In this strip is the quarter-inch hole *B* which is intended to fit over a stud placed in one of the holes in the sine bar button, while at *C* is an elongated slot which takes a clamping screw entering the center hole in the sine bar. In setting up the bar to a given angle, the edge *A* is placed on a surface plate and the sine bar adjusted in the regular way until the proper angle is secured, after which it is clamped into position by the screw which passes through it and the elongated slot in the plate. When setting up a vise on the milling machine, to produce a certain angle, the sine bar is held in the vise jaws as shown in Fig. 4, and the vise is swung until the blade passing by the contact point of an indicator *A* shows the vise to be set properly.

Sine Bar Principle Applied to an Angle-plate

Fig. 5 shows another application of the sine bar principle embodied in a convenient adjustable angle-plate for use in laying out, machining and inspecting angular work. Two hardened, ground and lapped bushings are placed in the position shown at *A* and *B*, the center distance between which is preferably to be in even inches, and their height from the base, when set square as shown, to be equal. In setting up a plate of this kind to a given angle, standard plugs are inserted in the two bushings and the measurement *D* ascertained with a height gage. After this, the sine of the angle, multiplied by the center distance between the two plugs, is added to the measurement *D*, and the plug in bushing *B* set accordingly, after which the setting is preserved by clamping the two halves of the angle-plate by bolts on each side of the fixtures, one of these bolts being shown at *E* in the illustration. In order to make the fixture more convenient, a table of direct-reading sines of degrees can be stamped on the surface *C*, and the arc *G* may also be graduated to degrees, while a pointer may be placed on the arm *H* for setting to approximate angles.

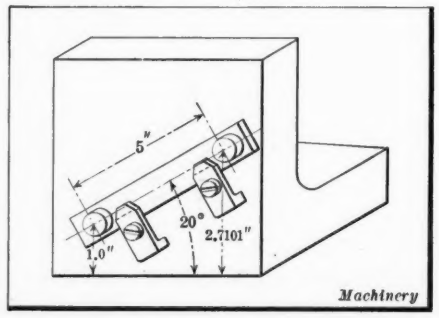

Fig. 7. Sine Bar applied to Simple Angle-plate

CONSTANTS FOR 5-INCH SINE BAR (Continued)

M	30°	31°	32°	33°	34°	35°	36°	37°	38°	39°	40°	41°	42°	43°	44°
0	2.5000	2.5752	2.6496	2.7232	2.7959	2.8679	2.9389	3.0091	3.0783	3.1466	3.2139	3.2803	3.3456	3.4100	3.4733
1	.5012	.5764	.6508	.7244	.7971	.8690	.9401	.0102	.0794	.1477	.2150	.2814	.3467	.4110	.4743
2	.5025	.5777	.6520	.7256	.7984	.8702	.9413	.0114	.0806	.1488	.2161	.2825	.3478	.4121	.4754
3	.5038	.5789	.6533	.7268	.7996	.8714	.9424	.0125	.0817	.1500	.2173	.2836	.3489	.4132	.4764
4	.5050	.5802	.6545	.7280	.8008	.8726	.9436	.0137	.0829	.1511	.2184	.2847	.3499	.4142	.4774
5	2.5063	2.5814	2.6557	2.7293	2.8020	2.8738	2.9448	3.0149	3.0840	3.1522	3.2195	3.2858	3.3510	3.4153	3.4785
6	.5075	.5826	.6570	.7305	.8032	.8750	.9460	.0160	.0852	.1534	.2206	.2869	.3521	.4163	.4795
7	.5088	.5839	.6582	.7317	.8044	.8762	.9471	.0172	.0863	.1545	.2217	.2879	.3532	.4174	.4806
8	.5100	.5851	.6594	.7329	.8056	.8774	.9483	.0183	.0874	.1556	.2228	.2890	.3543	.4185	.4816
9	.5113	.5864	.6607	.7341	.8068	.8786	.9495	.0195	.0886	.1567	.2239	.2901	.3553	.4195	.4827
10	2.5126	2.5876	2.6619	2.7354	2.8080	2.8798	2.9507	3.0207	3.0897	3.1579	3.2250	3.2912	3.3564	3.4206	3.4837
11	.5138	.5889	.6631	.7366	.8092	.8809	.9518	.0218	.0909	.1590	.2262	.2923	.3575	.4217	.4848
12	.5151	.5901	.6644	.7378	.8104	.8821	.9530	.0230	.0920	.1601	.2273	.2934	.3586	.4227	.4858
13	.5163	.5914	.6656	.7390	.8116	.8833	.9542	.0241	.0932	.1612	.2284	.2945	.3597	.4238	.4868
14	.5176	.5926	.6668	.7402	.8128	.8845	.9554	.0253	.0943	.1624	.2295	.2956	.3607	.4248	.4879
15	2.5188	2.5938	2.6680	2.7414	2.8140	2.8857	2.9565	3.0264	3.0954	3.1635	3.2306	3.2967	3.3618	3.4259	3.4889
16	.5201	.5951	.6693	.7427	.8152	.8869	.9577	.0276	.0966	.1646	.2317	.2978	.3629	.4269	.4900
17	.5214	.5963	.6705	.7439	.8164	.8881	.9589	.0288	.0977	.1658	.2328	.2989	.3640	.4280	.4910
18	.5226	.5976	.6717	.7451	.8176	.8893	.9600	.0299	.0989	.1669	.2339	.3000	.3747	.4291	.4921
19	.5239	.5988	.6730	.7463	.8188	.8905	.9612	.0311	.1000	.1680	.2350	.3011	.3661	.4301	.4931
20	2.5251	2.6001	2.6742	2.7475	2.8200	2.8916	2.9624	3.0322	3.1012	3.1691	3.2361	3.3022	3.3672	3.4312	3.4941
21	.5264	.6013	.6754	.7487	.8212	.8928	.9636	.0334	.1023	.1703	.2373	.3033	.3683	.4322	.4952
22	.5276	.6025	.6767	.7499	.8224	.8940	.9647	.0345	.1034	.1714	.2384	.3044	.3693	.4333	.4962
23	.5289	.6038	.6779	.7512	.8236	.8952	.9659	.0357	.1046	.1725	.2395	.3054	.3704	.4344	.4973
24	.5301	.6050	.6791	.7524	.8248	.8964	.9671	.0369	.1057	.1736	.2406	.3065	.3715	.4354	.4983
25	2.5314	2.6063	2.6803	2.7536	2.8260	2.8976	2.9682	3.0380	3.1069	3.1748	3.2417	3.3076	3.3726	3.4365	3.4993
26	.5327	.6075	.6816	.7548	.8272	.8988	.9694	.0392	.1080	.1759	.2428	.3087	.3736	.4375	.5004
27	.5339	.6087	.6828	.7560	.8284	.8999	.9706	.0403	.1091	.1770	.2439	.3098	.3747	.4386	.5014
28	.5352	.6100	.6840	.7572	.8296	.9011	.9718	.0415	.1103	.1781	.2450	.3109	.3758	.4396	.5024
29	.5364	.6112	.6852	.7584	.8308	.9023	.9729	.0426	.1114	.1792	.2461	.3120	.3769	.4407	.5035
30	2.5377	2.6125	2.6865	2.7597	2.8320	2.9035	2.9741	3.0438	3.1125	3.1804	3.2472	3.3131	3.3779	3.4417	3.5045
31	.5389	.6137	.6877	.7609	.8332	.9047	.9753	.0449	.1137	.1815	.2483	.3142	.3790	.4428	.5056
32	.5402	.6149	.6889	.7621	.8344	.9059	.9764	.0461	.1148	.1826	.2494	.3253	.3801	.4439	.5066
33	.5414	.6162	.6902	.7633	.8356	.9070	.9776	.0472	.1160	.1837	.2505	.3163	.3811	.4449	.5076
34	.5427	.6174	.6914	.7645	.8368	.9082	.9788	.0484	.1171	.1849	.2516	.3174	.3822	.4460	.5087
35	2.5439	2.6187	2.6926	2.7657	2.8380	2.9094	2.9799	3.0495	3.1182	3.1860	3.2527	3.3185	3.3833	3.4470	3.5097
36	.5452	.6199	.6938	.7669	.8392	.9106	.9811	.0507	.1194	.1871	.2538	.3196	.3844	.4481	.5107
37	.5464	.6211	.6951	.7681	.8404	.9118	.9823	.0519	.1205	.1882	.2550	.3207	.3854	.4491	.5118
38	.5477	.6224	.6963	.7694	.8416	.9130	.9834	.0530	.1216	.1893	.2561	.3218	.3865	.4502	.5128
39	.5489	.6236	.6975	.7706	.8428	.9141	.9846	.0542	.1228	.1905	.2572	.3229	.3876	.4512	.5138
40	2.5502	2.6249	2.6987	2.7718	2.8440	2.9153	2.9858	3.0553	3.1239	3.1916	3.2583	3.3240	3.3886	3.4523	3.5149
41	.5514	.6261	.7000	.7730	.8452	.9165	.9869	.0565	.1251	.1927	.2594	.3250	.3897	.4533	.5159
42	.5527	.6273	.7012	.7742	.8464	.9177	.9881	.0576	.1262	.1938	.2605	.3261	.3908	.4544	.5169
43	.5539	.6286	.7024	.7754	.8476	.9189	.9893	.0588	.1273	.1949	.2616	.3272	.3918	.4554	.5180
44	.5552	.6298	.7036	.7766	.8488	.9200	.9904	.0599	.1285	.1961	.2627	.3283	.3929	.4565	.5190
45	2.5564	2.6310	2.7048	2.7778	2.8500	2.9212	2.9916	3.0611	3.1296	3.1972	3.2638	3.3294	3.3940	3.4575	3.5200
46	.5577	.6323	.7061	.7790	.8512	.9224	.9928	.0622	.1307	.1983	.2649	.3305	.3950	.4586	.5211
47	.5589	.6335	.7073	.7802	.8523	.9236	.9939	.0634	.1319	.1994	.2660	.3316	.3961	.4596	.5221
48	.5602	.6348	.7085	.7815	.8535	.9248	.9951	.0645	.1330	.2005	.2671	.3326	.3972	.4607	.5231
49	.5614	.6360	.7097	.7827	.8547	.9259	.9963	.0657	.1341	.2016	.2682	.3337	.3982	.4617	.5242
50	2.5627	2.6372	2.7110	2.7839	2.8559	2.9271	2.9974	3.0668	3.1353	3.2028	3.2693	3.3348	3.3993	3.4628	3.5252
51	.5639	.6385	.7122	.7851	.8571	.9283	.9986	.0680	.1364	.2039	.2704	.3359	.4004	.4638	.5262
52	.5652	.6397	.7134	.7863	.8583	.9295	.9997	.0691	.1375	.2050	.2715	.3370	.4014	.4649	.5273
53	.5664	.6409	.7146	.7875	.8595	.9307	3.0009	.0703	.1387	.2061	.2726	.3381	.4025	.4659	.5283
54	.5677	.6422	.7158	.7887	.8607	.9318	.0021	.0714	.1398	.2072	.2737	.3391	.4036	.4670	.5293
55	2.5689	2.6434	2.7171	2.7899	2.8619	2.9330	3.0032	3.0725	3.1409	3.2083	3.2748	3.3402	3.4046	3.4680	3.5304
56	.5702	.6446	.7183	.7911	.8631	.9342	.0044	.0737	.1421	.2095	.2859	.3413	.4057	.4691	.5314
57	.5714	.6459	.7195	.7923	.8643	.9354	.0056	.0748	.1432	.2106	.2770	.3424	.4068	.4701	.5324
58	.5727	.6471	.7207	.7935	.8655	.9365	.0067	.0760	.1443	.2117	.2781	.3435	.4078	.4712	.5335
59	.5739	.6483	.7220	.7947	.8667	.9377	.0079	.0771	.1454	.2128	.2792	.3445	.4089	.4722	.5345
60	2.5752	2.6496	2.7232	2.7959	2.8679	2.9389	3.0091	3.0783	3.1466	3.2139	3.2803	3.3456	3.4100	3.4733	3.5355

M	45°	46°	47°	48°	49°	50°	51°	52°	53°	54°	55°	56°	57°	58°	59°
0	3.5355	3.5967	3.6567	3.7157	3.7735	3.8302	3.8857	3.9400	3.9932	4.0451	4.0957	4.1452	4.1933	4.2402	4.2858
1	.5365	.5977	.6577	.7167	.7745	.8311	.8866	.9409	.9940	.0459	.0966	.1460	.1941	.2410	.2866
2	.5376	.5987	.6587	.7176	.7754	.8321	.8875	.9418	.9949	.0468	.0974	.1468	.1949	.2418	.2873
3	.5386	.5997	.6597	.7186	.7764	.8330	.8884	.9427	.9958	.0476	.0982	.1476	.1957	.2425	.2881
4	.5396	.6007	.6607	.7196	.7773	.8339	.8894	.9436	.9967	.0485	.0991	.1484	.1965	.2433	.2888
5	3.5406	3.6017	3.6617	3.7206	3.7783	3.8349	3.8903	3.9445	3.9975	4.0493	4.0999	4.1492	4.1973	4.2441	4.2896
6	.5417	.6027	.6627	.7215	.7792	.8358	.8912	.9454	.9984	.0502	.1007	.1500	.1981	.2448	.2903
7	.5427	.6037	.6637	.7225	.7802	.8367	.8921	.9463	.9993	.0510	.1016	.1508	.1989	.2456	.2910
8	.5437	.6047	.6647	.7235	.7811	.8377	.8930	.9472	4.0001	.0519	.1024	.1517	.1997	.2464	.2918
9	.5448	.6058	.6657	.7244	.7821	.8386	.8939	.9481	.0010	.0527	.1032	.1525	.2004	.2471	.2925
10	3.5458	3.6068	3.6666	3.7254	3.7830	3.8395	3.8948	3.9490	4.0019	4.0536	4.1041	4.1533	4.2012	4.2479	4.2933
11	.5468	.6078	.6676	.7264	.7840	.8405	.8958	.9499	.0028	.0544	.1049	.1541	.2020	.2487	.2940
12	.5478	.6088	.6686	.7274	.7850	.8414	.8967	.9508	.0036	.0553	.1057	.1549	.2028	.2494	.2948
13	.5489	.6098	.6696	.7283	.7859	.8423	.8976	.9516	.0045	.0561	.1066	.1557	.2036	.2502	.2955
14	.5499	.6108	.6706	.7293	.7869	.8433	.8985	.9525	.0054	.0570	.1074	.1565	.2044	.2510	.2963
15	3.5509	3.6118	3.6716	3.7303	3.7878	3.8442	3.8994	3.9534	4.0062	4.0578	4.1082	4.1573	4.2052	4.2517	4.2970
16	.5519	.6128	.6726	.7312	.7887	.8451	.9003	.9543	.0071	.0587	.1090	.1581	.2060	.2525	.2978
17	.5529	.6138	.6736	.7322	.7897	.8460	.9012	.9552	.0080	.0595	.1099	.1589	.2067	.2533	.2985
18	.5540	.6148	.6745	.7332	.7906	.8470	.9021	.9561	.0089	.0604	.1107	.1597	.2075	.2540	.2992
19	.5550	.6158	.6755	.7341	.7916	.8479	.9030	.9570	.0097	.0612	.1115	.1606	.2083	.2548	.3000
20	3.5560	3.6168	3.6765	3.7351	3.7925	3.8488	3.9039	3.9579	4.0106	4.0621	4.1124	4.1614	4.2091	4.2556	4.3007
21	.5570	.6178	.6775	.7361	.7935	.8498	.9049	.9588	.0115	.0629	.1132	.1622	.2099	.2563	.3015
22	.5581	.6188	.6785	.7370	.7944	.8507	.9058	.9596	.0123	.0638	.1140	.1630	.2107	.2571	.3022
23	.5591	.6198	.6795	.7380	.7954	.8516	.9067	.9605	.0132	.0646	.1148	.1638	.2115	.2578	.3029
24	.5601	.6208	.6805	.7390	.7963	.8525	.9076	.9614	.0141	.0655	.1157	.1646	.2122	.2586	.3037
25	3.5611	3.6218	3.6814	3.7399	3.7973	3.8535	3.9085	3.9623	4.0149	4.0663	4.1165	4.1654	4.2130	4.2594	4.3044
26	.5621	.6228	.6824	.7409	.7982	.8544	.9094	.9632	.0158	.0672	.1173	.1662	.2138	.2601	.3052
27	.5632	.6238	.6834	.7419	.7992	.8553	.9103	.9641	.0167	.0680	.1181	.1670	.2146	.2609	.3059
28	.5642	.6248	.6844	.7428	.8001	.8562	.9112	.9650	.0175	.0689	.1190	.1678	.2154	.2617	.3066
29	.5652	.6258	.6854	.7438	.8011	.8572	.9121	.9659	.0184	.0697	.1198	.1686	.2162	.2624	.3074
30	3.5662	3.6268	3.6864	3.7448	3.8020	3.8581	3.9130	3.9667	4.0193	4.0706	4.1206	4.1694	4.2169	4.2632	4.3081
31	.5672	.6278	.6873	.7457	.8029	.8590	.9139	.9676	.0201	.0714	.1214	.1702	.2177	.2639	.3089
32	.5683	.6288	.6883	.7467	.8039	.8599	.9148	.9685	.0210	.0722	.1223	.1710	.2185	.2647	.3096
33	.5693	.6298	.6893	.7476	.8048	.8609	.9157	.9694	.0219	.0731	.1231	.1718	.2193	.2655	.3103
34	.5703	.6308	.6903	.7486	.8058	.8618	.9166	.9703	.0227	.0739	.1239	.1726	.2201	.2662	.3111
35	3.5713	3.6318	3.6913	3.7496	3.8067	3.8627	3.9175	3.9712	4.0236	4.0748	4.1247	4.1734	4.2208	4.2670	4.3118
36	.5723	.6328	.6923	.7505	.8077	.8636	.9184	.9720	.0244	.0756	.1255	.1742	.2216	.2677	.3125
37	.5734	.6338	.6932	.7515	.8086	.8646	.9193	.9729	.0253	.0765	.1264	.1750	.2224	.2685	.3133
38	.5744	.6348	.6942	.7525	.8096	.8655	.9202	.9738	.0262	.0773	.1272	.1758	.2232	.2692	.3140
39	.5754	.6358	.6952	.7534	.8105	.8664	.9212	.9747	.0270	.0781	.1280	.1766	.2240	.2700	.3147
40	3.5764	3.6368	3.6962	3.7544	3.8114	3.8673	3.9221	3.9756	4.0279	4.0790	4.1288	4.1774	4.2247	4.2708	4.3155
41	.5774	.6378	.6972	.7553	.8124	.8683	.9230	.9765	.0288	.0798	.1296	.1782	.2255	.2715	.3162
42	.5784	.6388	.6981	.7563	.8133	.8692	.9239	.9773	.0296	.0807	.1305	.1790	.2263	.2723	.3170
43	.5795	.6398	.6991	.7573	.8143	.8701	.9248	.9782	.0305	.0815	.1313	.1798	.2271	.2730	.3177
44	.5805	.6408	.7001	.7582	.8152	.8710	.9257	.9791	.0313	.0823	.1321	.1806	.2278	.2738	.3184
45	3.5815	3.6418	3.7011	3.7592	3.8161	3.8719	3.9266	3.9800	4.0322	4.0832	4.1329	4.1814	4.2286	4.2745	4.3192
46	.5825	.6428	.7020	.7601	.8171	.8729	.9275	.9809	.0331	.0840	.1337	.1822	.2294	.2753	.3199
47	.5835	.6438	.7030	.7611	.8180	.8738	.9284	.9817	.0339	.0849	.1346	.1830	.2302	.2760	.3206
48	.5845	.6448	.7040	.7620	.8190	.8747	.9293	.9826	.0348	.0857	.1354	.1838	.2309	.2768	.3213
49	.5855	.6458	.7050	.7630	.8199	.8756	.9302	.9835	.0356	.0865	.1362	.1846	.2317	.2775	.3221
50	3.5866	3.6468	3.7060	3.7640	3.8208	3.8765	3.9311	3.9844	4.0365	4.0874	4.1370	4.1854	4.2325	4.2783	4.3228
51	.5876	.6478	.7069	.7649	.8218	.8775	.9320	.9853	.0374	.0882	.1378	.1862	.2333	.2791	.3235
52	.5886	.6488	.7079	.7659	.8227	.8784	.9329	.9861	.0382	.0891	.1386	.1870	.2340	.2798	.3243
53	.5896	.6498	.7089	.7668	.8236	.8793	.9338	.9870	.0391	.0899	.1395	.1878	.2348	.2806	.3250
54	.5906	.6508	.7099	.7678	.8246	.8802	.9347	.9879	.0399	.0907	.1403	.1886	.2356	.2813	.3257
55	3.5916	3.6518	3.7108	3.7687	3.8255	3.8811	3.9355	3.9899	4.0408	4.0916	4.1411	4.1894	4.2364	4.2821	4.3265
56	.5926	.6528	.7118	.7697	.8265	.8820	.9364	.9896	.0416	.0924	.1419	.1902	.2371	.2828	.3272
57	.5936	.6538	.7128	.7707	.8274	.8830	.9373	.9905	.0425	.0932	.1427	.1909	.2379	.2836	.3279
58	.5947	.6548	.7138	.7716	.8283	.8839	.9382	.9914	.0433	.0941	.1435	.1917	.2387	.2843	.3286
59	.5957	.6558	.7147	.7726	.8293	.8848	.9391	.9923	.0442	.0949	.1443	.1925	.2394	.2851	.3294
60	3.5967	3.6567	3.7157	3.7735	3.8302	3.8857	3.9400	3.9932	4.0451	4.0957	4.1452	4.1933	4.2402	4.2858	4.3301

Machinery

Tables for Sine Bar Setting

The accompanying tables are useful for obtaining the correct setting of a 5- or 10-inch sine bar to produce a given angle. The method of using the tables is as follows: first, find the angle desired in the top row of figures and then look up the minutes in the left-hand column; the desired reading will be found at the intersection of the two columns. When used for a 5-inch sine bar, the figures may be read direct; if used for a 10-inch bar, the readings must be multiplied by 2 to give the correct figure.

Example:—Referring to Figs. 6 and 7, let a in Fig. 6 represent the angle of 20 degrees, R the radius of 5 inches or the distance between the centers of the buttons on the sine bar, and S the vertical height to set the center of one button above the other in order to get the desired angle. To find the height S look under the column headed "20 degrees" opposite 0 minutes and obtain the figure 1.7101, which gives dimension S. Fig. 7 shows a sine bar strapped to an angle-plate and set as above, 1 inch being added to the measurement 1.7101, as the lower button is 1 inch above the lower edge of the plate as shown by the dimensions given.

Many other applications may be made of the principles explained in this article, and the tables will be found useful in obtaining settings without resorting to the use of trigonometry.

* * *

MAKING PHANTOM VIEWS OF MACHINERY PHOTOGRAPHICALLY

One of the most effective ways of illustrating the construction of a machine is to show it in so-called phantom views, that is, with the frame or containing box outlined while the interior works are in natural tones. The copy for such illustrations is generally worked up by an artist, using the working drawings. The process is slow, tedious and costly, and for these reasons is seldom resorted to by machinery builders for the purpose of illustrating the construction and operation of their machines.

Although not much employed, there is a simple and effective photographic process for making phantom views which is quite feasible to use for small machines. The principle is simple. The machine or apparatus to be shown in phantom view is set up on a surface plate completely assembled. The heights of centers of shafts and other parts are taken with surface gages, and horizontal distances are measured from an angle-plate, so that when the frame or box containing the mechanism is removed, the latter can be replaced in exactly the same position as before.

A photograph is made of the assembled mechanism, or rather an exposure is made on the negative of about one-third the time required to make the complete exposure. The lens

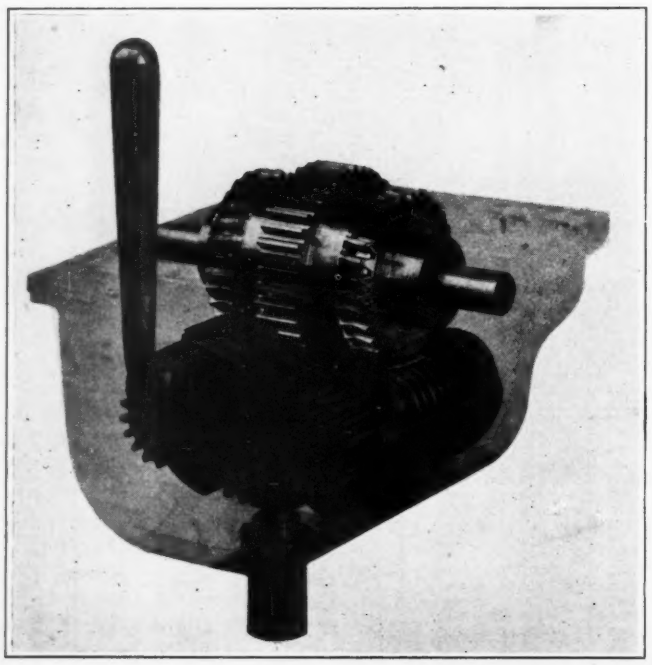

Fig. 1. Feed-box presented in Phantom View to show Construction

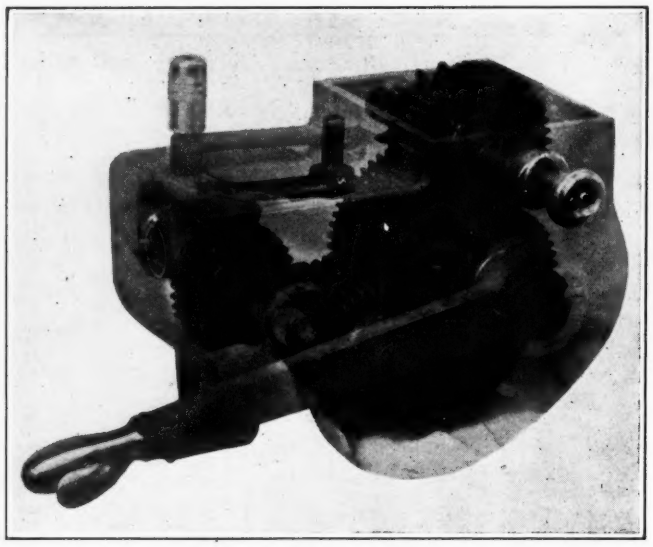

Fig. 2. Selective Type Sliding Gear Box photographed in Two Exposures to show Internal Construction

of the camera is closed and the machine is disassembled. The mechanism is then relocated on the surface plate by means of the surface gages and measurements from the angle-plate, so that it occupies exactly the same position with reference to the surface plate, angle-plate, and exposure on the negative as before. Then a second exposure is made with a full exposure, so that the interior mechanism is clearly shown in natural tones.

When the resulting negative is developed and printed, a print will be secured in which the frame or containing case faintly appears while the internal mechanism is clearly defined. It is evident that the method may be employed by anyone familiar with interior photography, who has some mechanical skill and the necessary means for setting up the machine and relocating the internal parts.

The accompanying illustrations, Figs. 1 and 2, show samples of phantom views kindly furnished for the purpose of illustrating this article by the Valley City Machine Works, Grand Rapids, Mich. Fig. 1 shows the case and interior of the single-lever feed control of a plain manufacturing milling machine, while Fig. 2 shows a selective type sliding gear feed change box. Both these views were reproduced without retouching, and hence show the exact photographic results obtained by the process described. It will be observed in Fig. 2 that the knob and gear at the upper right-hand portion of the view shows twice. This was due to the fact that in making a second exposure, the gear rolled over a short distance out of position before the exposure was fully completed. This serves to illustrate the effect obtained by double and triple exposures. This method of making phantom views is well known to machinery photographers in general, but is not as well known among the builders of machinery and those who have to make illustrated catalogues as it should be. It may be used profitably oftentimes to make difficult mechanical constructions clear, and wonderfully good results may be secured at a minimum cost.

* * *

SECOND QUEBEC BRIDGE DISASTER

The engineering world was startled in August, 1907, when the great cantilever bridge building to span the St. Lawrence River at Quebec fell, carrying upward of seventy men to their death. This disaster made engineers question the formulas for calculating the compressive strength of steel columns, and the result was the construction of a great testing machine at Pittsburg capable of imposing a load of 1,000,000 pounds and structurally fitted to test the compressive strength of full size columns. A few years later a second bridge was started by the Dominion government, of heavier design, which was to cost $17,000,000. The bridge was nearly completed, and on September 11 the 5000-ton center span was being hoisted in place when it fell into the river, killing eleven men. The cause of this latest disaster was due to a failure of one of the corner supports, which threw twisting and eccentric stresses on the members, causing rupture and total collapse.

LAPPING ARBOR CENTERS

The following on lapping arbor centers was prepared for a subscriber who wrote as follows:

> We have had considerable trouble lapping the centers of arbors, and would like to get any data available on an easier or quicker method of accomplishing this work.

There are two types of centers used in arbors. One is the straight vee or 60-degree angle and the other the rounded form which gives a line bearing. Of these, the rounded form shown at *B* in Fig. 1 is preferred by some small tool manufacturers. The reason that this type of center meets with favor is that an arbor provided with such centers can be used for either taper or straight turning with satisfactory results; furthermore, it will retain its accuracy for a greater length of time, as only a line contact is secured and it is not so easy for dirt to accumulate as in the straight 60-degree center.

There are various methods of lapping centers, the one used being governed to a certain extent by the type of center provided in the arbor. A few methods of lapping are shown in Figs. 2 and 3. The first method, shown in Fig. 2, illustrates how the lapping can be done in an ordinary speed lathe. The arbor to be lapped is held on the center, driven by a dog from the faceplate, and is supported on the outer end by means of a steadyrest. The lap is then held in the tailstock center of the lathe and is moved back and forth by hand, so as to prevent it from cutting grooves in the center. The lap should be made either from box-wood loaded with emery dust, or from copper charged with diamond dust. Unless the center has been carefully formed before hardening, and the hardening has been done in such a way as to prevent the center from distorting to any extent, this method of lapping is not entirely satisfactory.

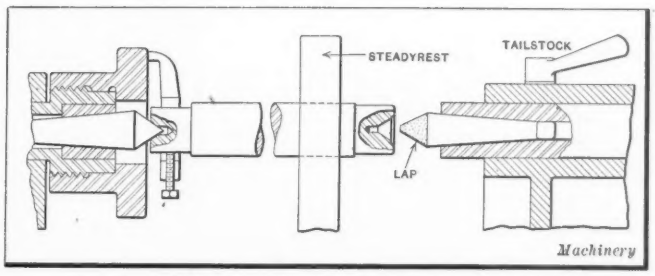

Fig. 2. Method of lapping Arbor Centers in a Speed Lathe

Another method of lapping is illustrated in Fig. 3. Here the work is done in a sensitive drilling machine, by holding the arbor in a special fixture in an upright position and the lap in the chuck on the spindle. The spindle is then given an up and down movement to prevent cutting grooves in the center; it is advisable to cut grooves in the lap extending toward the point to assist the lapping compound in spreading along the surface of the lap. Cutting helical grooves in the lap also increases the rapidity with which the work is accomplished.

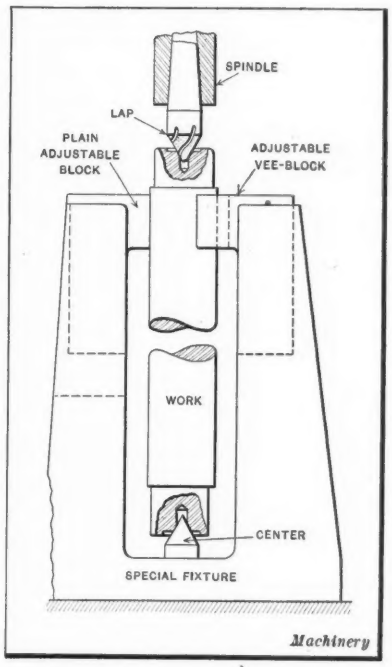

Fig. 3. Method of lapping Arbor Centers in a Drill Press

A still better method of lapping is to use a single-spindle valve grinder in which a much more satisfactory oscillating movement of the lap can be obtained. A drill press, however, could be fitted up with a device for accomplishing the same purpose. By securing an oscillating movement of the lap it will be found that the work is accomplished much more rapidly than when the lap is withdrawn and inserted into the center without any oscillating movement, and in addition there is less danger of scoring the center.

As has been previously mentioned, lapping of a center under the most favorable conditions is a tedious operation, and a highly satisfactory job cannot be obtained if the center is at all rough or distorted during the heat-treating operation. It will be found to be much more satisfactory to grind the centers. Considering first that the center is of the 60-degree type with a straight surface, there are two methods of grinding. That shown at *A* in Fig. 4 is to use a pencil wheel similar to that used for grinding gear-cutting hobs, and taper it down on the end to an angle of 60 degrees. This wheel should be rotated at a speed of not less than 10,000 R. P. M. In fact, the higher the speed the better the results. For this work, therefore, a No. 2 universal cutter and tool grinding machine provided with an internal grinding attachment could be fitted up. One end of the arbor could be supported and held on the driving center and the other end supported by a steadyrest, the pencil wheel being held in the place of the regular internal grinding wheel by making a special spindle for holding it. A pencil wheel of about 80 to 120 grain, grade O or P, should be used. Of course, the grade and grain of wheel will be governed largely by the condition of the center. If the center has been nicely finished before hardening, a very fine, hard wheel could be used and good results obtained, whereas if the center is rough and considerable material is to be removed in grinding, such a wheel would not give as satisfactory results.

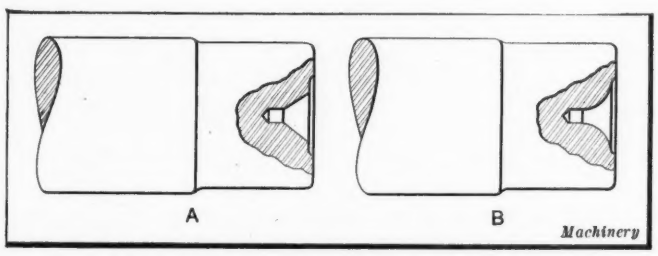

Fig. 1. Two Types of Centers for Arbors

Still another method of grinding an angular center would be to generate the center bearing as shown at *B* in Fig. 4. This also could be done on the same type of machine by simply setting the wheel slide at the required angle. This method of grinding will give much better results than that first mentioned. The center will be generated and can be made exactly to a 60-degree angle; in addition, a smoother surface will be obtained.

As has been previously stated, the straight center does not give as satisfactory results as one which is rounded off, and for grinding this center the pencil wheel could be formed by a radius diamond truing device and then brought in on the work the same as in grinding a 60-degree center.

The length of time required for lapping or grinding a center depends, of course, to a considerable extent on the method used and the finish required. Lapping a center in a speed lathe is a slow and tedious operation; lapping in a drill press with an up and down movement is a little faster; whereas lapping in a valve grinder is faster still. To lap a center correctly would require anywhere from fifteen minutes to a half hour, depending on the method used; whereas in grinding a center by the methods previously described the time could easily be cut to half or probably less. To grind two centers in an arbor by the generating process would require approximately ten minutes. To grind a rounded center with a form wheel would probably take about the same time, and if a satisfactory wheel were used it would not be necessary to true the wheel up after grinding each center. This method of forming wheels to definite shapes for grinding is being used more and more, and the grinding of tooth shapes of gears and hobs is a good example of the possibilities of form-wheel grinding.

Improvements are constantly being made, however, in the

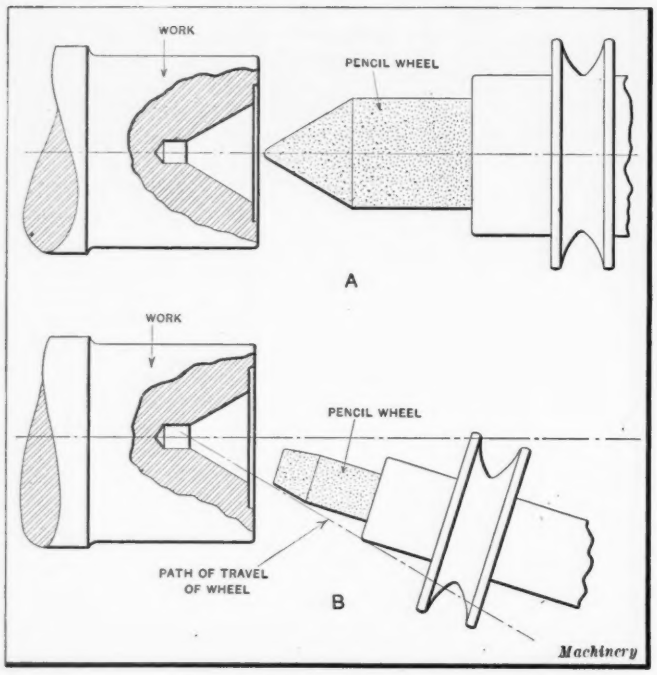

Fig. 4. (A) Form-grinding an Arbor Center; (B) Grinding an Arbor Center by the Generating Process

binders and methods of manufacture of grinding wheels, which tend to make possible the use of formed wheels for grinding shapes that heretofore could not be accurately finished after hardening with dispatch. D. T. H.

* * *

FORM GRINDING

It is not necessary that the face of the grinding wheel always be straight, as it is possible by the use of special truing fixtures and devices to shape the face of the wheel in a manner which makes it possible to grind forms in various kinds of work.

In form grinding, as in form milling, it is essential that the shape be continuous and uniform. It is impossible, of course, to grind under-cuts or varying shapes in a given form. Not every shape can be ground, any more than can every round piece of work be finished by the grinding process. Sharp corners should be avoided, not because of the inability of the truing device to shape a sharp corner, but rather because the small particles of grain and bond of the wheel which go to form the corner will not stand up and grind long enough to maintain such a shape. This follows because there is so much work required of so few particles of wheel that naturally they wear out and break away very quickly.

Still another factor, which must be considered in form grinding, is the varying depth of wheel face of the shape being ground. The wheel acts differently, of course, all along the form, depending on the distance that the cutting particles are from the center of the wheel, since irregular shapes in the face of the wheel cause the wheel to vary in diameter all along the width of the form, and if this variation in these diameters amounts to enough to vary the peripheral speed of the wheel materially at various points in the form, the wheel acts differently, and a uniform finish or rate of production cannot be maintained.

So that really the limitation in form grinding is governed by three things: The capacity of the attachment in producing varying shapes, the physical possibility of the grinding wheel to maintain a given form, and the depth of the hills and valleys in the face of the wheel, caused by the form, which affect the peripheral speed of the cutting particles.

The wheel must be trued frequently on form grinding to maintain the shape, especially where there are abrupt changes in the contour, such as sharp corners, small radii or deep cuts. Long sweeping curves or shapes which blend well into each other maintain their form more uniformly and for a greater length of time than do the more irregular shapes with sharp corners and angles. There are probably a great many machining operations now performed by other processes which could be readily accomplished by form grinding, effecting a saving in cost and producing a more accurate job with a finer degree of finish. The use of the grinding machine for this class of work is increasing as people come to realize the possibilities in shaping work which requires accuracy and good finish.

Flat work ground on a surface grinding machine can be formed just as well as round work on a cylindrical grinding machine. The only difference in these two methods of grinding is in the manner of handling the work. On the surface grinding machine the work is moved under the wheel on a reciprocating table; on the cylindrical grinding machine the table cannot be moved, and the wheel with the shape formed in it must be fed straight into the work.

One illustration of the usefulness of the formed wheel in producing shaped parts is in the crowning of pulleys. The crown can be made accurate within 0.001 inch on either diameter at the edges of the pulley, and the height of the crown can be much less than were it turned. The amount of power which can be transmitted through a belt running on pulleys crowned by a form grinding wheel is greater than can be transmitted by crowned pulleys formed by ordinary turning. Greater accuracy, the lesser height of the crown, and the fact that the face of the pulley has a uniform curve, cause the belt to adhere closely at every point along the face of the pulley.—*Howard W. Dunbar in Grits and Grinds.*

* * *

SHORT TIME FOR MACHINERY

The South Carolina Cotton Manufacturers' Association recently resolved to comply with the attorney general's construction of the law to the effect that the legal hours of labor in that state apply to machines. The opinion applied specifically to automatic cotton looms, which it has been the custom to allow to run during the lunch hour. Such slight attendance as the machinery needed was given by arrangements allowing the lunch hour at another time for the few employes who were needed for that purpose, their hours not being extended by the duty. According to the plain intent of the opinion, there must be the same hours for machines as for wage earners in South Carolina. A machine can work but 60 hours, and two men cannot be given the work of attending the same machine for 120 hours. There is a plain waste of capital needed for the larger number of machines, and there is a loss of work which might be given if it were lawful to work the existing machines longer hours. The interest of the general public does not lie in the creation of work or multiplication of jobs in this manner, but in the increase of product, and the tendency toward lower prices, resulting from the best use of the time of both men and machinery.

The case is not singular, as it might be thought. The same question arose over the automatic looms of the mills at Fall River. There the workers struck, not for shorter hours or higher wages for themselves, but for a reduction of the product of the machines. The case is not exactly the one sometimes alleged against capital, that machines and patents are held idle. There the machine or the patent which is best adapted for the use is employed, since it is not reasonable to use the worse when it is possible to use the better. Repeatedly it has been shown that the closing of factories and the disuse of inferior machinery or patents have been followed by an increase of product. That is to the interest of capital, and therein the interest of capital and that of the consuming public are identical. The matter of profit is less important than the production of goods, and if the production of goods should reach the sky—as it would not—there would be little objection to profits rising similarly. But increase of wages caused by waste of capital, and resulting in decreased production of goods, and increase of prices through increase of costs, are contrary to the public interest, and not so much to the interest of wage earners as labor leaders think and teach. Attorney General Peeples' opinion ought to be tested in the courts. If it is the law, it ought not to be allowed to remain the law. It is necessary to draw the line somewhere regarding legislation only nominally in the interest of labor, and actually contrary to the interest of every other portion of the community.—*New York Times.*

TRUNNION DRILL JIG WITH MILLING ATTACHMENT

The trunnion drill jig shown in Fig. 1 has mounted upon it a straddle-milling attachment for straddle-milling two bosses and cutting two oil slinger grooves in the lower half of an automobile crank-case. The crank-case is rigidly held in adequate supports in the drill jig, so that the light milling operation can be conveniently performed at the same time. The use of the jig for milling is also desirable, because the bosses must be in an accurate position in relation to the drilled holes. This drill jig was designed and is giving satisfactory results at the factory of the Knox Motors Co., Springfield, Mass.

In Fig. 1 the drill jig is shown in the loading position. The jig templet plate *A* has to be removed when the crank-case is being loaded onto the trunnion drill jig, as shown in the illustration. The crank-case is located by setting the outline to permanently located lines on the face of the jig. When the correct position is obtained, the crank-case is firmly clamped by four straps.

After the crank-case is clamped into position, the templet jig *A* is replaced, being held down by the hand-nut *B* and located by a keyway in its under surface and a key in the main body of the drill jig. While in the position shown in Fig. 1, the holes are drilled and tapped through the templet jig *A*, and this jig is allowed to remain in place, acting as a clamp, while the drilling and milling are being done with the jig in the position shown in Fig. 2. After the completion of the foregoing operation, the drill jig is indexed to the position shown in Fig. 2. While in this position, twenty-two holes are drilled in the crank-case, and after these are completed the milling is done.

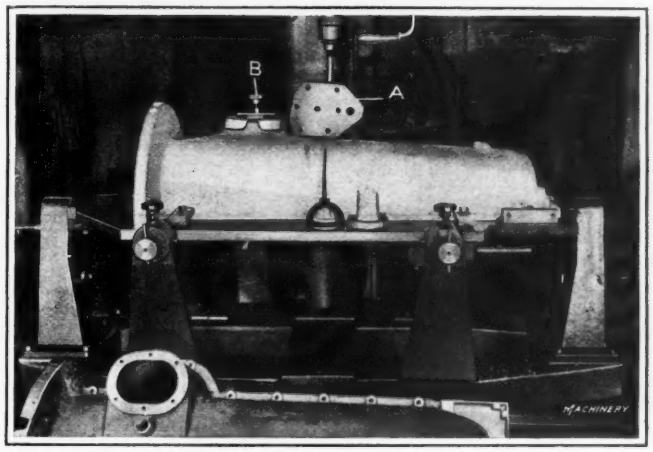

Fig. 1. Trunnion Drill Jig in Loading Position, showing Templet Drill Plate

The milling attachment for this drill jig consists of two members *D* and *C*. Part *C* consists of a body member for the milling attachment. In it are cut vertical ways in which the cutter carrying member *D* travels up and down. The movable member *D* carries a horizontal cutter-arbor having a gang of three cutters *J* and *G* on each end. In the center of this arbor is a bevel gear which meshes with another bevel gear carried by a vertical shaft, the upper end of which terminates in a Morse taper shank *E*. The movable member *D* is held normally in the upper position by springs.

In operation, the drill spindle is brought down in contact with the taper shank *E* until it is seated into the taper drill socket. Then the drill spindle is rotated, and the milling arbor, of course, rotates also through the bevel gears. The drill spindle is fed downward the same as for drilling, and in so doing the entire member *D* is lowered until the right-hand set of cutters *G* is brought into contact with the boss to be milled at the right-hand side of the crank-case. The cutters continue to be lowered until they come against a previously set stop, in which position the milling of the right-hand boss is completed.

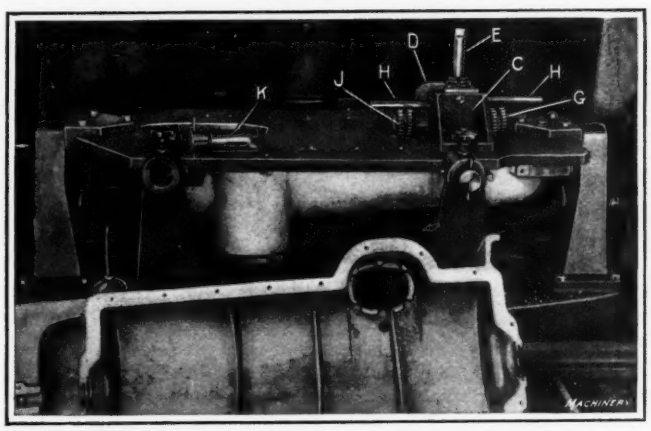

Fig. 2. Jig in Drilling and Milling Position, showing Milling Attachment

To proceed with the milling of the left-hand boss, it is necessary to loosen the straps that hold the milling fixture in place, grasp the handles *H* and lift the milling attachment over to the left-hand side of the drill jig, where there are dowel-pins which accurately locate it in its correct relative position. The operation is repeated in the same way as for the right-hand boss, except that cutters *J* are used instead of cutters *G*. This milling attachment is never removed from the drill jig, except as explained, for milling the right- and left-hand bosses. The movable member *D* is moved up out of the way by spring pressure when a new crank-case is being placed in the jig. It would be possible, of course, to equip this drill jig with two milling attachments, one at each end, so that it would not be necessary to move the attachment from one side to the other, but as the changing of the fixture from one side to another was such a simple matter, it was not deemed advisable to go to the extra expense that this would involve.

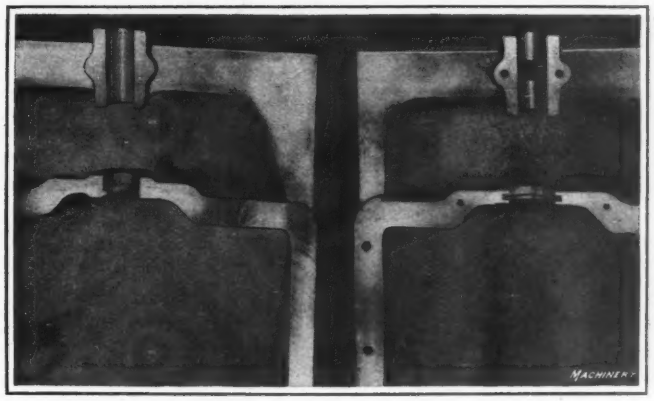

Fig. 3. One End of Crank-case before and after drilling and milling

Another point worthy of mention is the simple and efficient style of index plug that is employed on this drill jig. The construction of this index plug is clearly shown at *K*, Fig. 2. It consists of a circular plug with a concentric slot cut in it, the width of which is just the thickness of the drill jig plate. When the plug is in place and the drill jig is turned over, the slotted end is made to straddle the thickness of the drill jig plate which securely and accurately holds the jig in the correct position.

In Fig. 3 are shown two views of one end of the crank-case before and after drilling and milling. The exact nature of the straddle-milling and groove-milling is clearly shown. V. B.

* * *

It has recently been announced that the Navy Department intends to re-engine ships in the service that are now equipped with direct-connected turbines. The first two to be so reconstructed will be the destroyers *Henley* and *Mayrant*. These are to be equipped with geared turbine units, for which contracts have been placed with the Westinghouse Machine Co. of East Pittsburg, Pa. Geared turbines have been decided upon because of the fact that they are lighter and take up less space than direct-connected units, are much better mechanically because of their small size, and materially reduce steam consumption at all speeds, and especially at cruising speeds. This reduces the fuel consumption and increases the steaming radius, which is an important feature.

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GAGING AND INSPECTION METHODS

Modern developments in the machine shop have reached a point where problems of gaging and inspection are no longer left to haphazard systems evolved by this or that man, but are scientifically planned with a view to insuring a high production with interchangeability of parts. Many gages which have been used in times past have been of little use because they were not designed in such a way as to show variations. A "Go" and "Not Go" gage is all very well, but one which indicates the amount of variation in the work at the same time is still better. The present tendency is toward gages of an indicating type which give a reading by means of which it can be readily determined whether the tools are cutting large or small; hence the tools can be set to correct any error in one direction or the other.

The setting of tolerances and the determining of limits for work and inspection gages are of primary importance, requiring extreme care, unerring judgment and wide knowledge of manufacturing conditions, machine tools used and the sequence of operations on the work. It follows, therefore, that methods of gaging should go hand in hand with tool design. Inspection methods have kept pace with the progress in gaging, both in the testing of work in process and finished work. The daily and sometimes hourly inspection of the gages themselves and the care used to keep them in shape for accurate work have both been influential in securing the results which are obtained from present-day interchangeable manufacture. A system of gaging and inspection which does not take into consideration the wear on the gages and which does not include a rigid inspection of work gages at frequent intervals will fail to produce satisfactory results, no matter how carefully the original gages may have been made.

* * *

THREAD MILLING

Some valuable lessons have been learned by American manufacturers as the result of their experience in making shrapnel and high-explosive shells. One of these is the great efficiency of the thread milling cutter as compared with the single-point thread tool or taps and dies. Early in the game, some of our inexperienced concerns tried to thread shrapnel noses with single-point tools or taps to fit Whitworth thread gages. These attempts were commercial failures. It was practically impossible to hold single-point tools to the shape required and get the kind of thread demanded by the inspectors, and comparatively few taps and dies will cut Whitworth threads with the accuracy and speed required.

Thread milling solved the difficulties. The milling cutter made to the approved standard Whitworth thread section holds its shape and cuts rapidly. A shell mouth threaded with a milling cutter operated in a thread milling machine leaves little to be desired as regards accuracy, shape and smoothness of cut. No trouble is experienced in doing work that will meet the requirements of the inspectors armed with thread gages and a critical disposition.

Thread milling may be done with efficiency in a first-class engine lathe equipped with a cutter-head mounted on the carriage and provided with means for driving the cutter. While a makeshift arrangement of this sort is not to be generally recommended, the results are so highly satisfactory that one having used thread milling equipment on manufactured work ordinarily done with single-point tools could hardly be tempted to go back to the old time-consuming and inefficient way.

* * *

INTERCHANGEABLE PLANER WORK

One of the lessons learned by some in high-pressure production of machine tools to fill war orders is the economy of accurate machine work, especially planer work. Lathe beds may be planed very accurately on first-class planers by skilled mechanics, or they may be planed quite inaccurately by poor workmen on second-class machines. In the rush to produce machine tools, the tendency was to cut down the planer time, with the result that much more time was required on the erecting floor to correct the faults of planing. This obviously is bad management. One hour spent on the planer making a job right is as effective as five hours spent by the scraper to correct a poor job. When skilled erectors could not be obtained, the value of first-class planer work became more evident than ever.

A skilled workman on a good planer can readily produce plane surfaces parallel and in line with lateral dimension correct to within one-half thousandth inch limit, plus or minus. A scraping cut with a planer tool to make a surface true and of the required dimensions can be taken in a fraction of the time required by a skilled fitter to remove the metal with the file and scraper. In fact, good planer work obviates the need of scraping except to remove the iron dust and to harden the surface. Scraping is employed as a means for giving a beautiful finish, but as a corrective process in machine tool building it should not be greatly needed.

* * *

DIRT AND DISORDER IN SHOPS

Nothing is more depressing to an orderly mind than the sight of dirt and disorder in a machine shop. A shop in which castings are strewn promiscuously on the floor mixed with scrap, chips and waste, and where tools litter the work-benches and stands, is invariably associated with inefficiency and slovenly practice. It is true that a machine shop is a hard place to keep clean and orderly, but the expense and effort required are well repaid. Men work better and produce more when employed in cheerful surroundings where order reigns. The subjective influence is invariably for the better. A disorderly shop indicates a disorderly superintendent and begets disorderly habits in the workmen. A clean shop with tools kept right and castings neatly piled is potentially a safe shop, and inspires orderly methods.

An old shop need not necessarily look disreputable. The labor of one man rightly directed will accomplish wonders in brightening the windows, banishing dirt, sweeping away cobwebs and keeping the gangways free from obstructions. A patch of green grass in front neatly trimmed and a few vines trained to grow on the broken walls will repay a hundred times the cost. The man who sneers at these things as being "sissified" and out of place does not appreciate how powerfully they appeal to the esthetic side of man's nature or what a force they are in attracting desirable employes. Clean up regularly and keep the shop in order is a good rule to prevent accidents and fires and to promote general efficiency.

NOTES ON THE MACHINERY INDUSTRY ON THE CONTINENT

MACHINE TOOL BUILDING IN FRANCE, ITALY AND SWITZERLAND—WAGES AND COSTS OF MATERIALS

BY ALEXANDER LUCHARS*

THERE are not more than three or four machine tool builders in France at present—and at the outbreak of war there were only two of consequence. The facilities of these were totally inadequate to provide a fraction of the tools required, so America was virtually the only source of supply for machine tools. One of the two plants referred to has since been taken over by Schneider & Cie for the manufacture of special machinery, and the other, a lathe factory, is producing shells principally, so that virtually no machine tools are now being made in France or are likely to be made until the war ends.

I have heard a good deal about the increased output and great profits of American machine tool factories on account of war orders, but nothing at home approaches an example which I found in Paris. A manufacturer of gears whose shop I visited in July, 1914, and who was then employing about fifty men, obtained some huge government contracts for shells, and in connection with them a trifling loan from the government of 16,000,000 francs, which, with the help of friends, enabled him to enlarge his plant, so that he now employs 4500 hands—a large proportion of whom are women. What this enormous plant is to produce after the war is not yet evident. The difficulty of obtaining accurate information in Europe is shown by the figures given me as to the number of hands employed by this concern. One informant placed it at 12,000, another at 10,000 and a third at 8000; but careful inquiry showed that the actual number was about 4500. That is enough, without exaggeration. The same statement applies to figures on the increase in the cost of living in France. One highly intelligent French business man assured me that the cost of food had doubled, but I found that the advance was really about 30 per cent. The price of food in restaurants has increased about as much.

Some figures given me representing the sales of American machine tools in France are worth mentioning. The sales of the representative of one American manufacturing concern (not a dealer) during the two years of the war, in France and England, are said to have been 60,000,000 francs. The head of another firm which has a number of American agencies told me it had placed orders in America amounting to 35,000,000 francs.

France is a limited market for machine tools under normal conditions, and our manufacturers of course should not look for a continuation of anything like the business which has been passing during war time. In general, they do not appreciate how limited the market is for machine tools, and especially for large tools of a special character, so that when they have placed their agencies with a French concern and have not received the amount of business they looked for, they have been more inclined to blame the agent than the market.

Munitions Profits Dwindling

The enormous profits made in the manufacture of shells and other war material at the beginning of the war have dwindled, and some of the work is actually being turned out at a loss. Following are the prices of shells of the sizes most largely used:

Mm.	Inches	Prices 1914	Prices Now
75	2.95	15.00 Fr.	4.35 Fr.
105	4.13	22.00	12.50
120	4.73	28.00	12.50
150	5.9	32.00	18.50
155	6.10	36.00	20.00

The above quotations are for steel shells, and include machining, testing and gaging, but not material. The following table gives prices of shells made of "semi-steel," that is cast iron and scrap steel:

Mm.	Inches	Prices 1914	Prices Now
120	4.73	17.50 Fr.	11.00 Fr.
155	6.10	17.50	9.00

* Publisher of MACHINERY.

Some firms have sub-contracts for machining the 120-millimeter semi-steel shells at 3.75 francs each and are making a profit. The price paid by the government for machining only, is 7 francs. The price paid for the chips from these shells went, during the first six months of 1916, from 2.50 francs per 100 kilograms to 8.20 francs per 100 kilograms, and since has dropped to about 6.50 francs per 100 kilograms.

The first contracts for forging the loose head or ogive of 75-millimeter shells were given covering a period of about one year, not including heat-treatment, at 1.85 franc per shell with transport to and from the shop paid by the government. Today shops offer to do them, including heat-treatment, at 1.10 franc per shell; and some shops having a capacity of at least 6000 per day are seeking them at 65 centimes each, including the heat-treatment.

For fuses, 16.20 francs was paid for machining only, in 1914. Now the price is 6.80 francs. Detonators, for which 6.57 francs was formerly paid, are now 2.20 francs, including furnishing the metal; and 1.80 franc without the metal. Inspection of shells is much more rigid now than ever before. The prices have declined not only on account of competition, but also because the government inspectors saw the enormous profit in the work and gradually cut down the figures.

The first series of 3000 75-millimeter rifled trench cannon was placed at 1200 francs each for machining only; total labor cost, including jigs, tools, etc., 285 francs per cannon (based on a series of 1000 cannon). The second series was placed at 850 francs, for machining only. The labor cost was 325 francs per cannon. This model was more difficult to make, as the breech-block was screwed on instead of being forged integral with the barrel, and there were two copper slides set in the barrel.

At the beginning of 1915 the price for breech-blocks of 220-millimeter siege guns, machined after heat-treatment, was 1850 francs each. In November, 1915, the price for the same piece was 965 francs. The labor cost in each case was about 200 francs.

The first series of breech-locking rings of the 220-millimeter gun, machining only and not including heat-treatment, was placed at 1750 francs each. The second series was placed at 1290 francs. The pieces were made in series of 7 batteries (28 pieces). The labor cost, including tools, jigs, etc., was about 390 francs. The first series of breech-locking levers and firing levers of the 75-millimeter gun (not including heat-treatment) was placed at 146 francs for series of 300; second series in lots of 1500 at 112 francs; labor cost, including jigs, tools, etc., about 56 francs.

The reduction in prices paid for shells in the allied countries is an indication that the Allies have caught up with the demand. After two years of unparalleled exertion, they appear to have reached a point that the Germans were forty years preparing for. There are other indications of this condition besides the present prices of munitions. One is the enormous quantities of shells piled along the lines of the railways for miles in the rear of the firing lines. Everyone knows that it was the abundant supply of ammunition, as well as the men and the trained organization, which enabled the Germans to win during the early part of the war, and it is the more than abundant supply of ammunition, the constantly increasing supply of men from Great Britain and the close working relations of the Allies that have been turning the tide of battle. A French officer said that at the beginning of the war there was no ammunition for the cannon they had, and when they obtained ammunition they needed more guns. Now they have plenty of both.

I was told on good authority that no contracts for French shells or rifles had recently been placed out of France. The large contracts placed in the United States by the French government are said to have been for Russia, for which country France has been purchasing enormous amounts of war mate-

rial that is now supplementing the supplies that Japan has been furnishing, and partly account for the recent success of the Russian armies.

Wages and Prices of Materials in France

Wages in France vary according to location. The following wages are paid in a shop just outside Paris:

Position	Average Pay per Hour	Average Pay per Month	Average Pay per Month on Basis of 1 Franc per Hour
Inspector	0.79 franc	235.08 francs	275.37 francs
Assistant	0.52 "	155.10 "	187.38 "

In December, 1915, these men were all put on a basis of one franc per hour, to which are added the usual premiums and bonuses.

In the Department of Jura and in that region the maximum pay for both men and women is 7.50 francs per day of ten hours. The minimum for skilled men is 7 francs per day and tool-room men average 10 francs per day.

In the Paris district, which controls the pay of workmen as far north as Dunkirk and within a radius of about thirty miles in other directions, toolmakers were paid before the war from 90 centimes to one franc per hour, and since the war are paid 1.80 franc per hour. Lathe hands are now paid from 45 centimes to 1.40 franc per hour. Some shops about twelve miles out of Paris are paying 20 centimes per hour more to non-mobilized men, while those mobilized are paid the same rates as in Paris. In Amiens and the region of the Somme lathe hands are paid 65 to 70 centimes per hour. Schneider & Cie at Creusot pay 40 to 80 centimes per hour, and many of the workmen are refugees sent there by the government. There are said to be some 80,000 hands in the Schneider works in different parts of France.

In shell and fuse works the proportion of women employes ranges from 60 to 80 per cent. In such works most of the employes, except foremen and toolmakers, are usually women. From these figures the percentage runs down to 10. Women are generally paid wages varying from 5 to 6 francs a day with a premium, which increases the pay 2 or 3 francs. The proportion of women in some shops where the work is not heavy is as low as 30 per cent, and the government is trying to increase this percentage to 40, so that except on heavy work there will be no shops employing over 60 per cent of men. I have seen women employed turning out 120-millimeter shells, but in such cases they had hoisting apparatus and other appliances to help them with handling heavy material. Others were able to handle 75-millimeter shells without any such help.

The following table shows wages paid for various occupations in 1914:

Occupation		Wages per Day of 8 Hours, Francs Min.	Max.
Adjusteur de precision	Fitter, precision work	10.00	15.00
" ordinaire	Fitter, ordinary	7.50	10.00
Chaudronnier en cuivre	Coppersmith	7.50	12.00
" fer	Boilermaker	7.50	12.00
Chauffeur	Stoker	7.50	10.00
Conducteur, machines-vapeur	Engine driver	7.50	10.00
Calqueur	Tracer	7.50	10.00
Dessinateur	Draftsman	10.00	17.50
" autographe	Draftsman-copier	8.00	14.00
Forgeron de precision	Smith, precision work	10.00	15.00
" ordinaire	Smith	7.00	10.00
Frappeur	Smith's striker	6.50	8.50
Fraiseur de precision	Milling machine operator	8.00	12.00
Heliographe	Blueprinter	6.50	8.50
Manoeuvre	Laborer	6.50	8.50
Photographe	Photographer	8.00	14.00
Raboteur de precision	Planer operator	8.00	12.00
Tourneur de precision	Turner, precision work	10.00	15.00
" ordinaire	Turner	7.50	10.00
Menuisier modeleur	Patternmaker	8.50	13.00

On January 1, 1915, these salaries were all increased by 25 per cent. In addition to that increase, workmen are paid for premiums and overtime.

Here are a few changes in the prices of material in France since the war:

	1914-15	1915-16
Coal	34 fr. per ton	128 fr. per ton
Machine oils	75 fr. per 100 kg.	320 to 380 fr.
High-speed steel:		
(American)	7.50 fr. per kg.	42 to 56 fr. per kg.
(English)	7 fr. per kg.	16 to 28 fr. per kg.
Mild steel (Bar stock up to 2 in. diam.)	38 fr. per 100 kg.	Jan., 1916, 68 fr. per 100 kg.
Bronze castings, first quality	4.20 fr. per kg.	Jan., 1916, 6.50 fr. per kg.

Business and Engineering Conditions in Italy

In Italy business activity is divided into three zones or belts. The northern belt, which includes the manufacturing section, is very prosperous—probably more so than at any other period of its existence. In this belt lie the large machinery and automobile plants, all of which are turning out munitions; and hundreds of works of all kinds, big and little, are furnishing supplies for the army and navy. Because of the amount of money thus placed in circulation, and also because the northern belt is close to the fighting line and vitally interested in the outcome of the war, all the people there are enthusiastic for it. In the middle belt, where there is less metal manufacturing, there is less enthusiasm for the war. In the southern belt, which is farthest from the fighting line, and which is almost entirely devoted to farming and kindred industries, business is poor, and the war is unpopular. Flour mills are tied up on account of the scarcity of coal and the lack of water to run them. The farther south you go the less popular the war is.

Many of the motors that require oil for fuel are not operated on account of its lack, and old steam engines are being resurrected and started up, although the price of coal in some sections is almost prohibitive.

The demand for war supplies has naturally created an unprecedented market for all kinds of appliances needed in their production, including machine tools, so that other lines are indirectly affected as in England. Before the war, business was poor, money scarce, and most of the Italian automobile manufacturers, of which there are about a dozen, big and little, were guessing hard about the future. Now their production is limited only by the number of hands and machines they can procure. The great plant of the Fiat Co. at Turin has been extended until it comprises a small city in itself, employing from 15,000 to 18,000 hands, turning out shells, motor trucks, aeroplane and submarine engines, and other war material. The Isotta e Franchini, the Bianci and other smaller automobile manufacturers are running to their full capacity on about the same class of products.

It is said that the Fiat Co. plans, when the war is over and the demand ceases for war material, to produce a great variety of small metal products in general use, all of which have heretofore been bought from Germany, and also to build a low-priced automobile in large quantities. Probably when those plans were made they had not heard of the new Ford prices.

The Ansaldo works near Genoa is another immense manufacturing establishment, that and the Fiat works being the two largest in Italy. The Ansaldo works employ about 16,000 hands (more than double the number in 1914), of whom about 1000 are women. This concern was founded by two English engineers to make and repair engines for the Italian railways, and until recent years the management was associated with Armstrong-Whitworth of Elswick and conducted on the same lines, having its own steel plant and foundries, and building warships, torpedo-boats, motors, engines, cannon and machine guns, besides a variety of railway material. It is now under Italian control entirely and has produced an enormous amount of war material for the Italian army.

Notwithstanding the war, some progress in peaceful engineering works has been made in Italy. Some 300,000-horsepower turbo-generators have been installed along the Italian riviera, the power from which is carried long distances. The trains through the Mont Cenis tunnel, which until recently was filled with smoke, are now being operated by electricity. An interesting fact I noted was that the construction of their strategic railroads and much of the engineering work by the Italian army, including the tunnels under the impregnable San Sabotino mountain, one of the Gorizia defenses, have been done by Italians who were trained in America. There are said to be about 300,000 of them in the Italian army.

There are several machine tool builders in Italy; two or three make lathes and one makes gear cutters—none of much importance. The Italians have been only fairly large buyers of machine tools in years gone by, not having been fully educated to the advantage of using high-priced labor-saving machinery, except in the automobile works. A large part of the

metal-working machinery sold in Italy has been bought from Germany (about $1,500,000 worth annually), and many of the large German manufacturers were represented in Italy. This has, of course, all been cut off, and will certainly not be resumed during the war, and perhaps not for some time after. England and America will be called on for the metal-working machinery required in Italy until friendly relations are resumed with Germany.

Conditions in Switzerland

Little Switzerland, surrounded by four nations at war, obliged to maintain a large standing army and with her principal sources of income cut down, occupies a position of great difficulty and satisfies none of her neighbors. France and Germany both claim that she is trading with their enemies, and her visé on a passport immediately places the bearer under suspicion of being one of the spies with which Switzerland is said to be liberally supplied. It is worth noting, by the way, that Germany has made up a black list of Swiss firms who supply her enemies.

The hotel and lace industries on which Switzerland is principally dependent being virtually dead, she naturally has turned to the production of war material, which means everything that is used by an army, and all such industries are booming. The native language in the larger part of Switzerland being German, a smaller part French and a still smaller part Italian, it might be expected that the natural sympathies of the Swiss would be divided in like proportion, but I observed that they sold their products impartially to any foreigners, provided they paid in Swiss money. Foreign money is taken at a discount only.

The troubles of our manufacturers over raw materials are fly specks compared with what the Swiss manufacturers encounter. To obtain material from England, which is almost their only source of supply, they must first obtain one permit from the Swiss over-seas trust in London, a second from the English war department, a third from the English ministry of munitions, and a fourth from the French authorities for permission to land the shipment in France. Then their material must be shipped on Swiss railway trucks, for which they obtain a fifth permit from the French railway authorities. Incidentally, if any of this material is used for manufacturing war materials for an enemy country, the manufacturers are fined four times the value of the shipment and their names are stricken off the list of licensed importers.

There are four or five lathe manufacturers in Switzerland, and a dozen smaller machine tool builders, some of whom build bench drills. The largest machine tool factory there is that of the Société Suisse des Machines Outils d'Oerlikon, at Oerlikon, near Zurich, building lathes, horizontal boring and milling machines and vertical drilling machines, but not of the highest grade. Two years ago they were considered unimportant; one year ago they were employing about 300 hands, and now they employ about 500. They have sold thousands of lathes in France, and probably other thousands in Germany, Austria and Italy. One French dealer told me he had bought over a thousand; but added, "Because we couldn't get American." The French are always polite.

The Oerlikon Machine Tool Co. was formerly a department of the Oerlikon Maschinenfabrik, a large concern employing about 2500 hands, manufacturing locomotives, electrical plants and appliances, sand disintegrators, turbo blowers, train lighting equipment and other peaceful material. This concern makes no war material and so keeps out of trouble.

The wages for machinists and other metal workers in Switzerland are naturally less than in the surrounding countries, and as many of the best workmen attempted to leave Switzerland to get the higher wages offered by foreign works, an order was issued by the Swiss war department forbidding the granting of furloughs to any soldiers—and, of course, all able-bodied men in Switzerland are soldiers—for the purpose of leaving the country. This made so much feeling among the workmen that strong pressure was brought to bear on the authorities, and Switzerland being a republic where politics have more influence than in some other countries, the order was modified.

THE DECAY OF METALS*

By decay of metals is meant changes of an unfavorable character that take place when in use or in storage, especially those that proceed completely through the mass of the metal. The simplest of these is the disintegration due to molecular change of the kind known in chemistry as allotropic. This is especially observable in tin, which becomes unstable at 64.4 degrees F. and may gradually change from a tough white metal into a gray powder. This condition is first manifested as small spots at which mounds of gray powder soon appear. In a short time, each spot becomes a hole, which rapidly perforates the metal. A peculiarity of this trouble is that it rapidly spreads from one place to another, like an infectious disease; it is therefore known as the "tin plague." In cold countries like Russia, the tin roofs of the affected areas are quickly destroyed when the process of decay is started. It seems as though the powder must be carried by the wind, and that wherever it settles it starts the tin decaying. Tin is also likely to undergo a molecular change at the temperature of boiling water. This is shown by the columnar structure that is frequently found in pieces of broken condenser worms. Allotropic changes occur also in lead, especially lead sheets subjected to the application of solutions containing lead salts. This change does not appear to be connected with the impurities in ordinary lead, as it seems to occur as readily with common sheet lead and the purest assay foil.

Decay may also be due to the movement of gases dissolved in a metal. This is the cause of the brittleness of nickel wires used as resistances in electric furnaces. The heating of the wire sets free the dissolved gases invariably contained in nickel. As the cooling between two periods of use is too rapid for a complete reversal of the process, a part of the gas remains undissolved between the grains of metal. As this alternate heating and cooling continues, the grains separate and the wire crumbles.

Severe cold working of a metal is apt to produce the form of decay known as seasoning cracking. Hard drawn brass rods and tubes occasionally crack, both in use and in storage, when transferred to a warmer climate or exposed to slight corrosion. This decay is due to the existence of severe internal stresses in the metal caused by the unequal deformation of the inner and outer layers. The cracks are commonly transverse. While seasoning cracking is generally hastened by exposure to temperatures above normal, heating sometimes prevents this form of decay. Seasoning cracking may also be caused by ammonia or other agents; when the chemical agent acts rapidly the cracking may occur with almost explosive violence. Very hard drawn rods of brass or bronze will sometimes fly to pieces when attacked with a solution of a mercury salt or of ferric chloride.

Sometimes cracking is started by superficial corrosion, the corroding agent separating the grains of the surface layer, acting in the same way as a crack. At the same time internal stresses may increase the liability of corrosion by opening up cleavages in the grains, thus effecting a path along which the corroding agent may enter, even though the stresses may not have produced any cracks.

Corrosion is accelerated by the contact of dissimilar metals. As a single metal in the annealed and cold-worked conditions differs in its electrical properties, the contact of the two favors corrosion, so that a metal which is locally cold-worked is particularly likely to corrode. For this reason the corrosion of a cold-rolled metal takes place in such a way that the rolling lines become clearly visible, pitting or grooves appearing in a direction parallel with that of rolling.

The corrosion of alloys that contain two or more solid constituents is of a special character. It usually starts in the form of minute pits, which are quite close to the minute masses of the compound and parallel to them in outline. This type of decay is most clearly observable in those alloys of copper and zinc that consist of two solid constituents—the yellow metals, including muntz metal, delta metal, manganese bronze, etc.

* Abstract of paper read before the Institute of Engineers and Shipbuilders, in Scotland, by Cecil H. Desch.

BRASS AND BRONZE AIR CONTAINERS

S. D. Sleeth, superintendent of the foundries of the Westinghouse Air Brake Co., Wilmerding, Pa., presented a paper before the American Institute of Metals at Cleveland, Ohio, September 11-15, in which he discussed the conditions necessary for the production of non-porous castings and gave the constituents of three alloys for containers that have to withstand internal air pressure, like air brake parts, etc. Density and strength are the two qualities necessary in a metal suitable for the retention of air or other gases under pressure, and while strength may be secured through proper design, density is a quality not so easy to obtain. Density of a brass or bronze casting is affected by a number of variables, among which are the design of the article to be cast, the design of the pattern with reference to its position in the flask, composition of the alloy, treatment of the metal in the furnaces and temperature of the metal when poured.

All cross-sections of the part should be of approximately equal thickness in order to prevent draws of heavy portions. If this is not possible, access to all large sections should be provided for the use of chills to prevent draws. If the cored cavities are large, the cores themselves will act as chills. Fillets should be as small as possible in order that excessive masses of metal shall not be concentrated at one point.

The use of chills is almost always necessary. Chills should be used on all enlarged sections in close proximity to smaller sections and connected thereto. If the sections are exceptionally large, sinking heads on top of the large sections should be used. The molds should be gated with a heavy upright pouring gate as near the pattern as possible. The gate leading from the pouring gate to the pattern should be made large at the pouring gate and then reduced sharply into the pattern. If it is left large where it joins the pattern, in all probability it will show a draw in the casting at the gate. As a rule, it is better to gate in a light part of the casting than in a heavy portion. If a sinking head is used, it should be placed on the heavy part.

The treatment of the metal in the furnaces is of vital importance. If proper allowance for oxidization on zinc, etc., is not made, the alloy required will not be produced. The metal must be taken from the furnace as soon as it reaches the proper heat, for if allowed to soak in the furnace, it will take up gases, and the castings made from it may be porous. In pouring certain packing ring mixtures, the Westinghouse Air Brake Co. considers the time so important that an alarm clock is used to insure the metal being poured at exactly the right moment.

The temperature at which the metal should be poured is also vitally important; no doubt many castings are lost due to carelessness in this matter. If poured too cold, it is almost impossible to obtain solid castings, especially at the gates. On the other hand, if poured too hot, castings may be porous throughout. Great care must be taken to see that no aluminum is used in the mixture, as a very small percentage of aluminum will cause the castings to leak. Antimony and iron will do the same, but not to so great an extent. Aluminum has a peculiar action on the metal. The castings will appear solid and will not show a draw, but when under pressure will leak all over.

The following compositions have been tried and found satisfactory for air containers:

Metals	No. 1 Alloy	No. 2 Alloy	No. 3 Alloy
Copper	72.50	82.00	83.00
Tin	1.75	7.50	11.50
Zinc	19.25	4.75	4.00
Lead	6.50	5.75	1.50
Total	100.00	100.00	100.00

No. 1 alloy is used for ordinary castings, such as cocks, pistons, bushings, etc. It is easily machined, but is not suitable for very high pressures. No. 2 and No. 3 alloys are suitable for high pressures and are harder to machine than No. 1.

* * *

The one-hundredth anniversary of the making of the first Remington rifle was celebrated in Ilion, N. Y., August 29, 30 and 31. The first Remington rifle was made by Eliphalet Remington in 1816 in his father's blacksmith shop.

RYERSON SAFETY-FIRST CONTEST

In the plant of Joseph T. Ryerson & Son, Chicago, Ill., the matter of safeguarding the workmen in every possible way has been given careful attention. Machines have been provided with guards; dangerous places have been plainly marked; large instruction signs have been posted in conspicuous places as well as safety bulletin boards telling of accidents and how to avoid them, and not infrequently the men receive further instructions and advice by letters in their pay envelopes; inspections of machinery, equipment, etc., are made every week. In addition, safety committees have been appointed to consider safety measures and enforce safety rules. The latest scheme adopted by this company to stimulate the interest in safety work is a safety-first contest, open to all workmen, to be effective from June 1, 1916, to May 31, 1917. This contest is an adaptation of the Dodge plan and is carried out under the following rules:

Rating Plan

Records are based on the fewest number of accidents which cause days lost after the day on which the accident occurs, and also on the fewest number of days lost after the day on which the accident occurs. A standard of 1000 points is set up for a perfect record. To attain this record, workmen or departments must have no accidents causing the loss of full days. To compute the standing of various departments and individuals, the following penalties are charged:

Penalties

For each accident causing a full day's absence after the day of the accident, a number of points is deducted from 1000 equal to the ratio of one man to the total number of men in the department. For instance, in a department with 100 men this will equal $1/100 \times 1000 = 10$ points.

For each day lost on account of accident after the day of the accident, a number of points is deducted from 1000 equal to the ratio of one day's time to the total number of days all men work in the department. For instance, in a department of 100 men working twenty-five days per month, or a total of 2500 working days, this will equal $1/2500 \times 1000 = 0.4$ point. No department, however, will be penalized for more than thirty days' lost time on any one accident.

For fatal accidents, or accidents causing loss of fingers, toes, limbs, eyes, or permanent disability, a penalty of thirty days' lost time is charged in the month the accident occurs.

After all penalties for accidents have been deducted from 1000, and all penalties for days lost have been deducted from 1000, the remainders will be added and divided by 2. After the results have been considered, the rewards, based on the records, are made as follows:

Rewards

The department having the highest record in a month is given the guardianship of a prize pennant, to be held by it for one month, and hung on exhibition in some suitable place.

All men who have worked one year in the department which for the year maintains the highest record are rewarded by sixteen hours' time off with full pay, equal to a Friday and Saturday. All men who have worked in that department less than one year, but nine months or more, are rewarded with ten hours' time off with full pay.

All men not working in the winning department but who have a record of 1000 points for the year, not having had an accident which caused a full day's loss of time, will be rewarded by sixteen hours' time off, with full pay, equal to a Friday and Saturday.

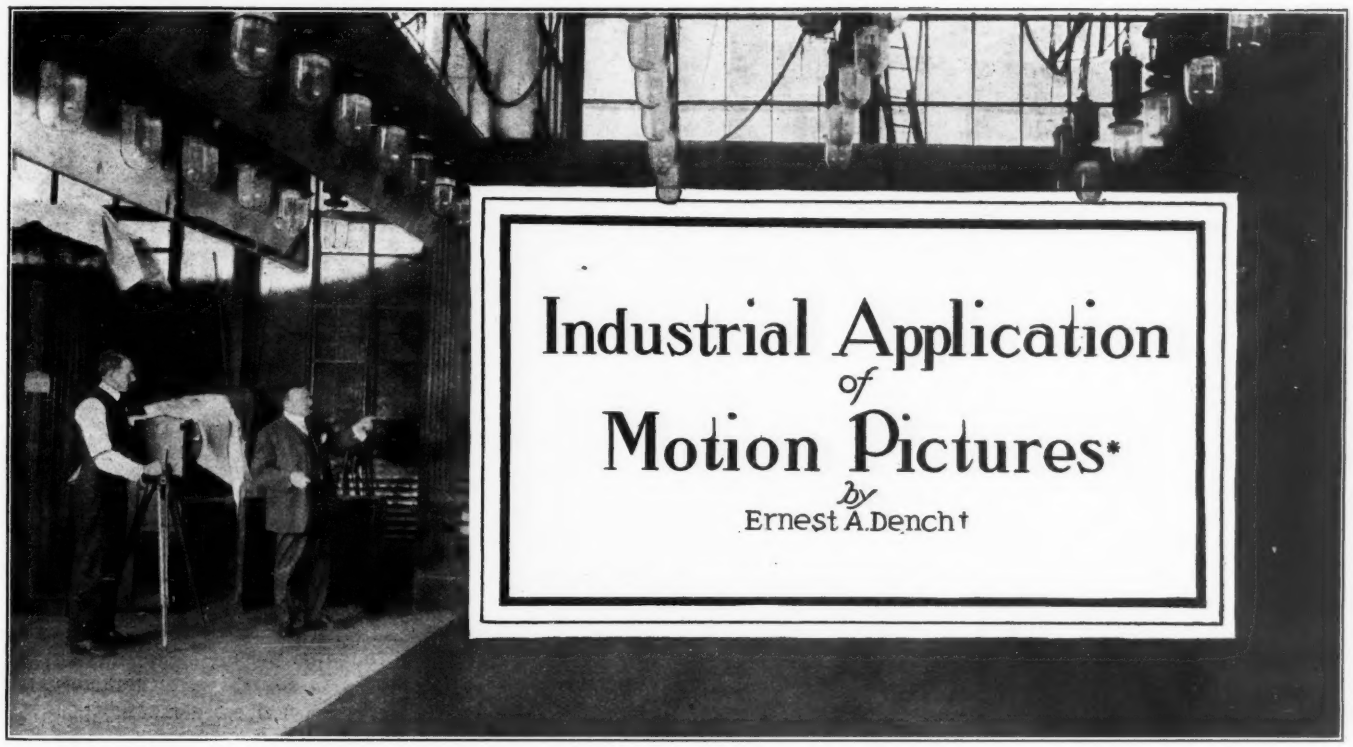
The rewards constitute either time off, as described above, or its equivalent in wages, whichever the management decides to be the best arrangement.

Foremen of the winning department for a month are rewarded by an addition of 5 per cent to their monthly bonus, or if they have no schedule, 5 per cent of their monthly wages.

The foreman of the department which wins the annual prize is rewarded by a prize to be chosen by the executive committee.

* * *

Newark, N. J., which celebrated the 250th anniversary of its founding by Robert Treat this year, is so near New York that its commercial importance is overshadowed. Comparatively few know that it has over 6000 manufacturing concerns and over 250 different lines of industry employing over 75,000 operatives. The capital invested in manufactures approximates $160,000,000, and the value of the raw material used yearly aggregates $130,000,000, the annual output being valued at $225,000,000. The chief industries are leather, machinery, iron and steel goods, shoes, corsets, chemicals, varnishes, thread, smelting, paints, hardware and clothing.



Industrial Application of Motion Pictures*

by Ernest A. Dench†

THE high degree of perfection which has been attained in the production and exhibition of moving pictures has made going to "movies" a popular pastime for a great many people. This is generally thought to be due to the fact that it is such an inexpensive form of amusement; but low cost would certainly fail to make an appeal were it not for the fact that it is possible to prepare films that show the most minute details of all scenes with an absolute degree of accuracy. Popularity of the "movies" and their ability to show details with absolute fidelity have led to their application by manufacturers for a great variety of purposes, and it is the intention of the following article to describe a number of typical instances, with the view of suggesting a wider application of an industrial development that has shown itself to be unusually effective.

Those who have made a study of the application of motion pictures in industrial work state that the following are requirements that must be fulfilled in order to secure satisfactory results: (1) In order to be of technical value, the films must be specially prepared for the purpose, with a full recognition of educational requirements; and they must comply with the fundamental necessity of showing the process in a manner that will make clear the exact nature of all the details involved. (2) Pictures must be supplemented by a technical explanation given by an expert in the subject that is being illustrated. (3) The film must be shown under conditions that will enable it to be stopped as required, so that in cases where the subject calls for fuller explanation this can be given. (4) All views must have a serious scientific or technical interest, as a film prepared for the purpose of amusing or entertaining an average audience would be quite unsuitable for the education of technical students.

The Film as an Instructor

One of the most obvious applications of motion pictures is in the educating of young men for industrial work, and it has been suggested that the method could be applied with exceptionally satisfactory results in explaining the work of a trade to boys who make application for apprenticeship, in order that they may fully understand the conditions under which they will have to work. Many such boys take up a trade without knowing in the least whether it is likely to prove congenial, and after a few months a number of them become discouraged and look for employment elsewhere. This has not only resulted in the loss of valuable time for the boy, but his employer has also suffered a financial loss, as it is generally known that the expense of training an apprentice during the early stages of his indenture amounts to much more than the value of his work.

It is felt that the motion picture, appealing to the eye as it does, would constitute a very satisfactory means of giving all boys who make application for apprenticeship an adequate knowledge of just the kind of work they will be called upon to perform, and that the ones who are likely to become discouraged and leave at an early stage of their career would thus be prevented from starting upon a course which would result in mutual loss to themselves and their employer. The Bureau of Commercial Economics has this subject under consideration, and if present plans are completed, it is the intention to show "trade teaching" films in such places as public schools, mission houses, settlement houses and other places where young men congregate, in order that knowledge of working conditions in various trades may become more general. The expense of preparing and showing these films will be provided by endowment funds and annuities.

For purposes of education, the use of motion pictures is by no means confined to apprentices. The Carnegie Institute of Technology, Pittsburg, Pa., presents a course in the metallurgy of iron and steel by the use of films prepared for that purpose; and the reader may judge how completely the subject is covered by the title of this film, which is "From Iron Ore to Finished Steel." The first pictures show the Mesaba District of Minnesota, where many celebrated iron ore mines are situated. Mammoth steam shovels are seen engaged in digging ore which is loaded onto lake boats at Duluth and shipped to various southern lake ports. After finishing the subject of mining, the scene changes to Farrell, Pa., at the works of the United States Steel Corporation, where various steps in the smelting, refining and rolling processes are clearly illustrated, as well as the recovery of numerous by-products. This is but one example of the use of motion pictures in the curriculum of technical institutions, but it illustrates the possibilities for this line of work.

Those institutions which are engaged in the technical education of young men are generally located in industrial centers, and part of the curriculum consists of making what are known as "inspection visits" to various industrial works, the idea being to show students the practical application of processes and manufacturing methods which they have studied in classrooms and laboratories. Where this method is followed, the

* For information relating to moving pictures and their industrial application previously published in MACHINERY, see "On Producing Mechanical Moving Pictures," February, 1915; "How Moving Pictures are Made," February, 1915; "Moving Pictures of Automobile Building," March, 1914; "The Moving Picture in the Machine Tool Business," January, 1914, and articles there referred to.

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choice of industries is naturally limited to those located within a reasonable distance; but in some cases the alternative has been adopted of preparing motion pictures of industries which may be selected without attention to their location, and showing these pictures in connection with lectures delivered in class-rooms, instead of taking the students to the factories. An advantage is found in the fact that the time required in going about from one plant to another is saved, and it is also said to be easier to hold the student's attention in a class-room than in a factory. The College of Mechanical and Electrical Engineering, Lexington, Kentucky, has prepared a motion picture course of this kind, which includes the following subjects: "Natural Resources of the Canadian Rocky Mountains"; "Construction and Operation of the Panama Canal"; "Electrification of the Butte, Anaconda & Pacific R.R."; "Motor Construction and Direct Motor Drive"; "Schenectady Works of the General Electric Co."; "Pittsfield Works of the General Electric Co."; "Manufacture of Curtiss Steam Turbines"; "Mining Iron Ore"; "Making Wire and Wire Fencing"; "Manufacture of Pipe, Tubes and Pipe Fittings"; "Use of Concrete in Road Making"; "Manufacture of Steel, Tin Plate and Tin Products"; "America in the Making"; "Playgrounds and Welfare Work of the Carnegie Steel Co."; "Welfare Work in Mining Districts."

The European war has produced some unusual labor difficulties which have been solved in part, at least, by the application of motion pictures. Crippled men have been classified according to their injuries and suitable employment found for men of each class. Then, in certain cases, motion pictures have been used to illustrate the movements required for performing the new work, this having been the means of teaching the men their new duties very rapidly.

Studying Efficiency by Means of Motion Pictures

Many manufacturers have tried timing their men on certain operations, but in many cases it has been found difficult, if not impossible, to secure reliable data, as no two mechanics work in the same way. The results obtained in timing two mechanics may be equal, and yet the manufacturer may feel certain that neither employe is turning out his work in a short enough time; but the evidence of the stop watch does not afford any means of deciding why men are incompetent. The micro-motion cinematograph, on the other hand, provides a record which may be taken to the office of the efficiency engineer and studied at leisure, in order that each move made by the workman may be carefully analyzed to show just where he is at fault. The disadvantage in making time and motion studies is that the workman knows he is being watched; but it is probable that the error from this cause is about neutralized by taking observations on a number of different men, as some will endeavor to make the best possible showing with the view of improving their standing with the firm, while others will work slowly with the idea of preventing an unduly high piece-work rate being placed upon an operation.

In making a motion picture time study, sixteen separate pictures, or "frames," as they are technically called, are obtained for each foot of film; and each picture represents an exposure of 1/32 second. If the time and motion study is to be conducted successfully, two clocks should be used, one of which is an ordinary alarm clock and the other a clock especially constructed for the purpose. Frank B. Gilbreth, of New York City, has developed a special clock for this purpose which has only one hand that covers the dial every six seconds. With this clock, time intervals may be noted down to 0.001 minute, the dial of the clock being subdivided into one hundred parts. The alarm clock serves to show the time taken in completing the job, while the special clock enables each motion to be accurately timed. These clocks are placed on a table or bench, so that they may be shown in the film that records the movements of the workmen, and it is important that all tools and appliances should be so placed that the workman will have every advantage in making a satisfactory showing.

In conducting tests of this kind, the efficiency engineer has the films developed and studies each frame through a magnifying glass, which enables him to detect the difference between a necessary motion and one that is useless. This is found beneficial because each movement may be thoroughly studied, whereas if the film were run off on a screen in the usual way it would not be possible to stop it at any particular place when it was desired to study the movements.

Emphasizing Necessity of Careful Packing by Use of Motion Pictures

In developing export trade, it is absolutely necessary for manufacturers to pay careful attention to the question of packing their goods for shipment. This fact was emphasized by Consul James Oliver Laing of Karachi, who suggested that motion pictures would afford many valuable object lessons in bringing this point home to American manufacturers. To quote Mr. Laing, "If a single photograph of a smashed packing case or of a lighter full of goods being landed brings the story home to a manufacturer, a moving picture showing how the case came to be smashed or how goods are put into or taken out of the lighter would be many times as effective." Everyone knows that cases are sometimes smashed, and a single photograph merely shows the result, while moving pictures would emphasize the relation of cause and effect. For instance, suppose a shipper of flour could see a lot of Levantine stevedores swing a loop full of sacks over the side of a ship and let it down on the run to a flat boat bobbining about on the waves. The sight of what happens when the boat suddenly rises to meet several hundred pounds of muslin sacked flour would be an object lesson to any shipper. Similarly, if an American furniture merchant could see a moving picture of his packing cases being dropped from a cart tail to a stone pavement by a gang of Maltese dock hands, he would appreciate the necessity of providing substantial packing cases for his goods.

How Motion Pictures Can Assist the Sales Manager

The manufacturer of heavy and cumbersome machinery and other products is placed at a decided disadvantage in showing his goods to prospective customers. His salesmen cannot take samples to the customer's factory or office, and it is difficult, if not impossible, to have his product shown at conventions, trade shows or similar gatherings of men whom he desires to interest in his product. For such manufacturers, motion pictures are a great aid in improving selling efficiency. Until recently salesmen in the employ of manufacturers of such products depended upon their selling ability aided by photographs, drawings and data in regard to the operation of machinery or other equipment which they were selling. Where the "prospect" wished to see a machine in operation, it was customary for the manufacturer to pay his traveling expenses to visit the plant, but this practice proved exceedingly expensive and often took much, if not all, of the profit from the deal. The modern method is to have the salesman provided with films showing all parts of the machine, the assembled machine in operation and details of the manner in which it works. The salesman is equipped with a small portable projecting machine with which he can show these films, and in this way he is able to show his customer every detail of a machine in which he is interested. There is no loss of time traveling to and from the factory, and no danger of a deal falling through as a result of salesmen being provided with insufficient information. Many American manufacturers are now using this method with extremely gratifying results.

The Reo Motor Car Co., Lansing, Mich., had a film made which serves three useful purposes. This picture shows manufacturing operations in the company's factory and illustrates how various important parts of the car are made. A private motion picture theater has been erected in the company's office building, in which this picture is regularly exhibited to employes—especially salesmen—in order to keep these processes fresh in their minds. The result is that they are able to talk with assurance that carries conviction, due to having a thorough knowledge of the goods which they have to sell. This film has also been found valuable for sales demonstration purposes, and with certain minor changes has been made suitable for showing to the general public.

Other motor car manufacturers have made considerable use of moving pictures. For instance, the Ford Motor Co., Detroit, Mich., had a film developed to show how a complete Ford car

was assembled in two and one-half minutes and driven away on its own power. The Pierce-Arrow Motor Car Co., Buffalo, N. Y., also uses a film which shows in a convincing manner the power and capability of its pleasure cars and trucks. As it is not always possible to conduct an adequate demonstration of a motor truck in the street, this film proves a valuable adjunct to the sales organization. Anyone who contemplates purchasing a car at the Los Angeles branch of the Studebaker Corporation cannot help being favorably impressed by the films which are shown in that office. They show the new Studebaker "Six" climbing up Big U mountain, a location which is favored by Nature for the purposes of motion picture producers. Everything goes well until the car has completed half of its trip up the incline; then it begins to slide back, but the wheels finally secure a grip, and after raising a good deal of gravel and stone, the car completes its ascent. The American Laundry Machinery Co. recently developed a film which shows various operations in modern laundering, and this film is offered free to any responsible person engaged in the laundry business.

Advertising with Motion Pictures

More for the purpose of advertising than anything else, the Winchester Repeating Arms Co., of New Haven, Conn., induced those two crack shots, the Topperweins, to demonstrate their wonderful marksmanship with rifles, pistols and shot guns before the moving picture camera. At the end of the film spectators are also given a number of views in the Winchester plant, where the well-known "Red W" line of arms and ammunition is manufactured.

Where machinery manufacturers resort to the use of moving pictures in a publicity campaign, the general practice is to have pictures made to show processes involved in manufacturing the product and finished machines engaged in the performance of those classes of work for which they are intended. Such pictures show a prospective customer both the care which is taken in manufacturing the machine and the features of its design which are likely to prove of exceptional benefit to him. In such pictures no attempt is made to introduce comedy or dramatic incidents, but an ingenious scenario writer can sometimes conceive an interesting story which is worked into the film, thus making it more entertaining to the average spectator and giving power to attract and hold interest. In many commercial undertakings there are interesting events that can be utilized by an expert in producing films for use in advertising this system. It must be clearly understood, however, that such films are, as a general thing, only applicable for advertising machines like automobiles that have a general market, and would not be of value in advertising machine tools and other forms of manufacturing equipment.

Fig. 1. Pig Iron stored in Maxwell Foundry

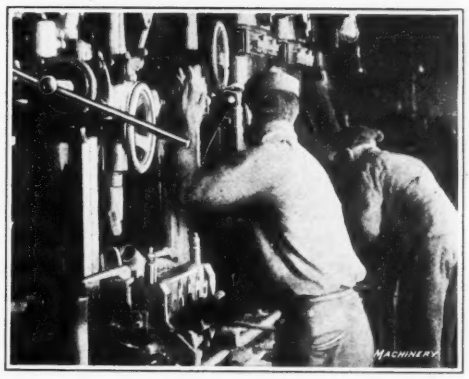


Fig. 2. Drilling Operation on Maxwell Cylinder Block

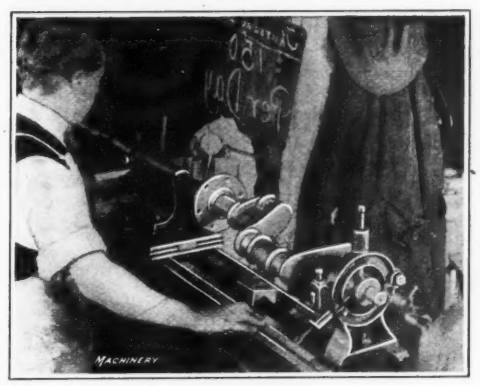


Fig. 3. Machining a Maxwell Crankshaft

Fig. 4. Testing Finished Maxwell Cars

Fig. 5. Maxwell Motor Car on the Road

This form of film was recently used by the Maxwell Motor Sales Co. in carrying on an advertising campaign. The film started in this company's factory, where the spectator was shown various steps in the manufacture of a Maxwell car; and this section was followed by pictures showing a tour through California, in which a human interest story was cleverly incorporated. This film was shown in over five thousand different towns in America, Canada, Australia and England, and it is estimated that it was seen by fully two million people. This circulation was attained through cooperation with dealers who made arrangements with local moving picture theaters and presented free tickets to all who desired to make use of them. The dealers reported that these films proved to be of great assistance in "boosting" sales, and that they were the means of finding many new customers.

Another important use of moving pictures is at various trade shows. It is a common practice for machinery manufacturers to ship heavy machinery to such exhibitions and hire the required amount of floor space to show it in operation. This is an expensive matter, as it calls for shipping charges, rent for floor space and traveling expenses of men sent to erect and operate the machines. But even when all this trouble and expense have been taken, the result obtained is often unsatisfactory, owing to lack of space, inadequate facilities, etc. To overcome these difficulties, motion pictures are now being used as a substitute, and the results are highly satisfactory. In all buildings where such exhibitions are held, electric light is available, and it is an easy matter to construct a temporary dark-room in which pictures can be exhibited. Films used in this way can be made to show a manufacturer's product to the best advantage, and so he is certain of showing prospective customers the best results which they can hope to secure from the use of his machine.

Cost of Producing Industrial Motion Pictures

The production of good films of industrial motion pictures means a great deal more than merely obtaining a batch of explanatory views. The first step taken by the manufacturer who desires to obtain the best possible results is to secure the services of a reputable motion picture producer. The term "reputable" is used intentionally, as there are many producers who are none too scrupulous, and who make a regular practice of charging for superfluous "footage," which is designated as "padding" in the motion picture industry. The extra cost of such material is not represented merely

by the extra cost which the manufacturer has to bear, as the introduction of such views in his films detracts greatly from the interest, and so robs him of much of the publicity value which he would otherwise secure. The great thing is for the films to have a continuous snappy action, for if it is unduly drawn out, the spectator is likely to lose interest. If material for one reel is strung out to occupy two reels, it simply means that an audience is bored for forty minutes instead of being entertained for twenty minutes. In making all films there is sure to be a certain amount of useless material introduced, but such views are cut out of the films before they leave the producer's laboratory.

It goes without saying that moving pictures are intended to be shown quite rapidly, and if the film is burdened with a mass of explanatory matter, it requires greater mental concentration to absorb the idea, and, consequently, the value of the advertising is lessened. For this reason, the fewer and shorter the sub-titles used in a film the better the picture will be. It is well to bear in mind that it is what a spectator sees—not what he reads—that leaves a lasting impression; and so motion picture producers should aim to convey the required ideas by the action in the film wherever this is possible, instead of showing "cut-ins" which explain the idea in words. Advertising experts usually agree that the use of moving pictures is not a paying proposition as regards direct returns secured for the expenditure; but their use in creating a demand for a new product is said to be highly satisfactory. Of course, this is another case in which the statement applies solely to the advertising of products which have a general market; in the case of machine tools and other classes of manufacturing equipment, the use of moving pictures should be confined to showing machines to those who are likely to become purchasers, and here the efficiency of the method is naturally much higher.

In starting to prepare a film for publicity purposes, the best plan is to have the representative of a reputable film producer call at your plant in order that you may explain your views and show him just what phases of the work you desire to have covered. With this information in hand, he will proceed to lay out a film, and if it is planned to introduce some form of story, it will also be necessary to draft the scenario in which one or more scenes will be allowed for each process of manufacture, according to its relative importance. A "scene" is understood to refer to any portion of the film which can be made without moving the camera, and for unimportant details five feet of film may be made to suffice, while the showing of important processes may require as much as fifty feet of film. Where sub-titles are used, each word requires about one foot of film, so that, in addition to being unsatisfactory for the reasons already referred to, it will be seen that the introduction of many sub-titles involves considerable expense.

A competent camera man commands from $10 to $20 a day, and is paid for time when weather conditions delay the work of production, so the producer will include this item when making his estimate. Lighting conditions in a plant may be unsuitable for photographic purposes, and in such cases the producer will have to figure on installing a portable electric lighting outfit for doing his work. The producer must also figure on the cost of raw materials, waste footage of film, the work of developing negatives and printing positives, office expenses and overhead, to all of which he must add his own legitimate profit. Taking these items into consideration, the average cost of an industrial film is in the neighborhood of $1 a foot, or $1000 for a reel of average length. This only includes the work of producing and developing the negative, ten cents a foot being charged for each positive that is made. Whether more than one positive will be needed depends upon circumstances, but if the film is to be shown in various parts of the country at the same time, it will be necessary, of course, to arrange for a number of positives.

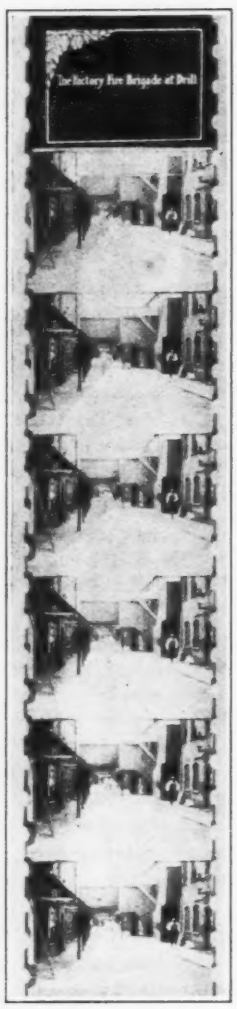


Fig. 6. Fire Drill

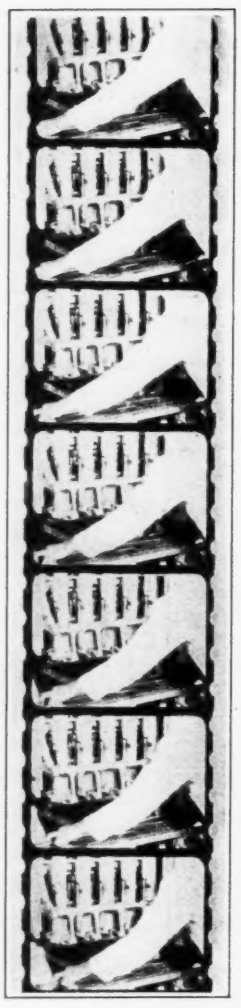
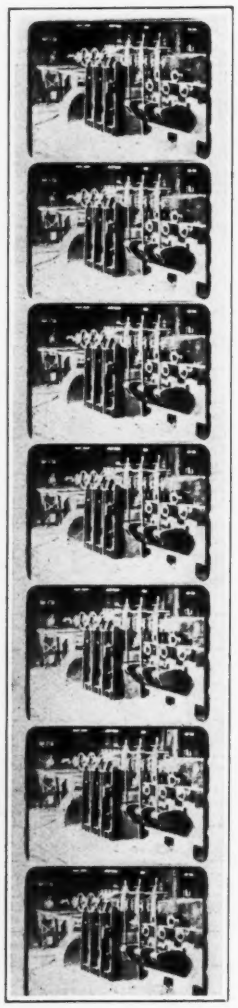


Fig. 7. Motion Study

Figs. 8 and 9. Drawing and Straightening Shelby Tubing



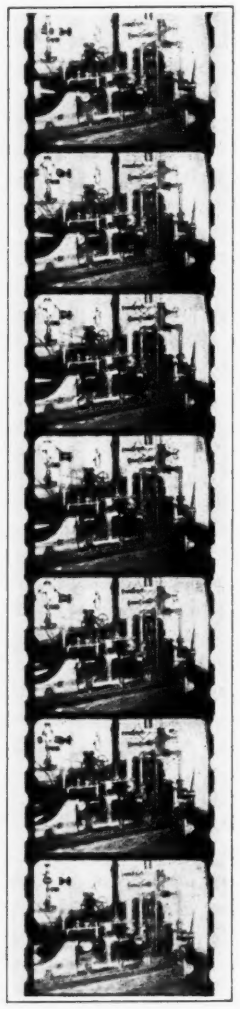


Fig. 10. Power Plant

The time required to complete the actual work of "filming" is frequently of the utmost importance, as delays caused in the rate of production in busy factories may be more important than the actual cost of making the film. The shortest possible time in which a camera man can record 1000 feet of film is eighteen minutes, but this does not allow for a single stop. Let us suppose the camera man is to show fifteen separate details for a one-reel picture, and that seven of these details are to be taken in the plant with the aid of a portable arc light to provide the necessary illumination. This means that he has to set his camera in fifteen different positions, but as he will frequently run a "close-up" as well as a full scene of each process, it will be seen that it is necessary to make thirty stops. He is trying to give good service and knows that if he hurries unduly and "shoots" the scene without planning the method of securing the best results, the final effect is likely to be extremely crude. If a single scene is unsatisfactory, it can be retaken; but if fifty feet of film is involved in this scene, it means an extra outlay of about $50. Based on the experience of those who have been making industrial films for some time, it is safe to say that five minutes for each scene is about the average time that camera man should take, so the making of a one-reel film should occupy about 1¼ hour.

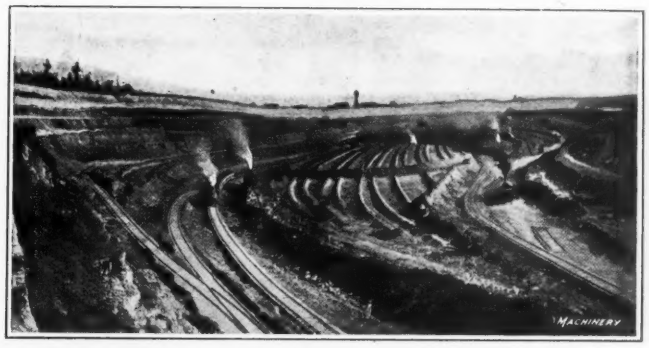


Fig. 11. Mining Iron Ore used in making Shelby Seamless Tubing

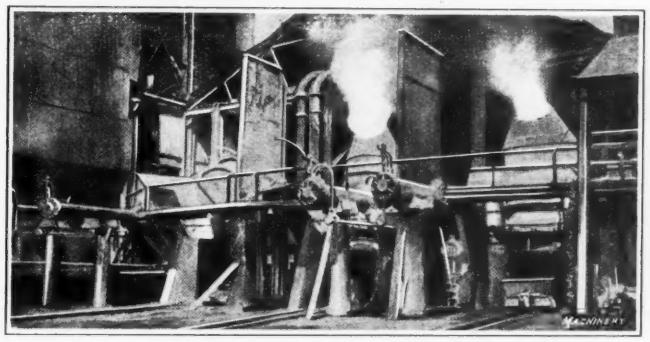


Fig. 12. Bessemer Converters used in refining Steel

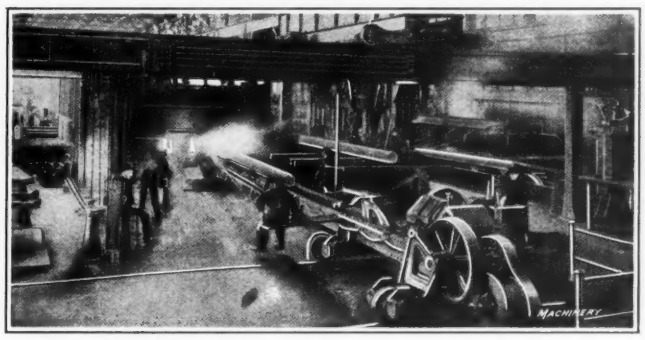


Fig. 13. Making Shelby Seamless Steel Tubing

Making films for the comedy or dramatic photoplay is more involved and expensive than for the work which has just been described. The first essential is to secure a good story, and based on his experience as a scenario writer, the author is prepared to say that a fee of $100 is not unusual for this part of the work. The writer of industrial motion picture scenarios must have a keen appreciation of advertising value and the ability to develop a dramatic incident to the maximum of its possibilities. After the idea has been developed, a cast of actors and a talented director must be employed to produce a play, if it is to have a distinct professional touch. It is probable that the interior of the plant cannot be used for some of the scenes, and this will incur the expense of fitting out a studio to resemble the plant's interior. The cost of producing such photoplays naturally varies with the different conditions which are encountered, but all the essentials mentioned should be provided at a cost somewhere between $1.25 and $3 per foot. This works out at a cost of $1250 to $3000 for producing a negative for a reel. When a negative has once been produced it is always available for use, but it is a mistake to permit a "print"—which is another name for a positive—to remain in constant use for more than six months, for after that period it generally enters the "rainy" stage, when it no longer leaves a good impression.

Equipping a Private Motion Picture Theater

There are several conditions which may make it desirable for a manufacturer to have a motion picture theater in his own plant. It has already been mentioned that some manufacturers—particularly builders of automobiles—find it desirable to show moving pictures for the benefit of their employes and of prospective customers. Then there are many factories that assist their employes in the maintenance of club rooms in the factory, and there are few forms of entertainment that will be more appreciated than good motion pictures. In either case, one of the first requirements is to provide a room in which pictures can be shown to the best advantage. In selecting space which can be converted into a satisfactory photoplay theater, the following points should be borne in mind. First, the room should be lofty, well ventilated and large enough to comfortably accommodate the full number of people who are likely to be present. Second, it should be free from all such obstructions as pillars and other supports. Third, it should be on the ground floor, as fire regulations in many states prohibit giving motion picture shows on the upper floors of a building. Fourth, there should be at least four exits, which must open outward in order to conform with fire laws. Fifth, it is advisable to divide the rows of seats into sections, so as to provide two aisles, one at each side; and these aisles should be not less than three feet wide.

If the building is constructed of wood, this does not necessarily make it unsuitable; but in order to guard against fire risks, the walls and ceiling should be covered with some form of fireproof material, such as metal ceiling. It is essential for the chairs or benches to be fastened to the floor as a precaution against congestion in the event of a fire panic; and it is customary to allow a floor space of four and one-half square feet for each person. Before installing a private theater, the best plan is to go over the details of installation with a representative of your fire insurance company, as ordinary fire insurance policies can hardly be expected to cover this special risk. In various parts of the country, fire underwriters insist upon the projection machine being enclosed in a fireproof booth, so that if there is an outbreak of fire, it will not spread to other parts of the building. This involves an expense of about $65, but the protection provided is well worth the investment. The booth is generally constructed of galvanized iron and made large enough to give the operator plenty of room to work; it is shipped in parts and may be easily set up with nuts and bolts.

The following outlines the best forms of projecting machines and gives their approximate costs: (1) The Edison "Kinetoscope" may be safely recommended, because it can be easily manipulated with little experience and stands up well under hard service; it is made in two models, one of which sells for $155 and the other for $250. (2) The distinguishing feature of the "Cameragraph" No. 6-A is that it is provided with a special device which lessens danger from fire; this machine costs $250. (3) The "Simplex" has many desirable features in its construction, which include simplicity of design and protection against fire hazards; the cost is $300. (4) The "Edengraph" is noteworthy on account of the fact that it

produces perfect projection when operated by an experienced attendant, several special features being provided that are not found on other machines; the selling price is $250. (5) The "Motiograph" is popular, owing to its durability and to the broad guarantee which is given to the manufacturers of this machine. In addition, there are several miniature machines on the market, but their use is limited because of the fact that it is only possible to obtain satisfactory results when the picture is thrown on a small screen located close to the machine. They are intended for use at home or for the use of traveling salesmen. Among a number of satisfactory equipments of this type, the following may be mentioned: (1) Bang's "Home Entertainer," which costs $70. (2) The "Baby Simplex," constructed on the same principles as standard machines and which is simple to operate; excellent results are obtained with the five- by seven-foot screen located twenty feet from the machine; the cost is $65. (3) The "Pathescope," which throws a picture six feet on a screen three by four feet in size; this instrument has been approved by the National Board of Fire Underwriters.

In operating a projecting machine it is necessary to use electric arc carbons, and these may be bought to best advantage in cases containing 1000. After providing the machine, the next point is to furnish a suitable screen on which to project the pictures. In the byegone days, a bed sheet or table cloth was used, but there are now special screens that give far more satisfactory results. Among these may be mentioned the Silver Fiber, which is superior to cloth screens in that no clouds or other defects appear on the film. The Silver Fiber screen and curtain are attached to a frame that may be easily placed in position; the material is sold at fifty cents a square foot, $20 being charged for the frame. Next comes the employment of a skillful operator to run the machine, for if the film flickers or gets out of focus, the audience is more than likely to become disgusted and leave before the entertainment has been completed.

A regular motion picture operator commands a salary of from $15 to $25 a week for an eight-hour day. A manufacturer may have a man in his employ who is well versed in electrical work, and it is often possible to have him taught the fundamentals of operating a motion picture machine, so that he will be able to combine this with his regular work.

In selecting a suitable lens, the size of the room, type of projecting machine, length and height of screen, and distance from operating booth to screen must be taken into consideration. It is false economy to purchase a cheap lens; and when ordering a lens the details just referred to should be given, in order that the order may be filled intelligently. The picture should be focussed exactly in the center of the screen to avoid the necessity of having spectators compelled to sit in an unnatural position. The standard speed at which pictures are projected is sixteen "frames" per second, and there are sixteen of these frames to each foot of film. The operator should be provided with a tool outfit which will include cement for mending broken films, files for sharpening carbons, an outfit of reels, and machine oil for lubricating all bearings and other running parts of the machine. Most motion picture machines are operated by electric light, but in those cases where electricity is not available, calcium carbide may be used to generate acetylene gas for the purpose. An acetylene generating outfit can be bought for $35, and it is important to note that the gas can be generated without provision of forced pressure; the generator can be put in operation in five minutes and has a capacity of generating gas with a candlepower of 700.

Selection of Suitable Films

Where a motion picture theater is provided in a factory to furnish entertainment for employes during the evenings, too much attention cannot be paid to the selection of those films that are likely to prove most entertaining. Out of the large number of films which are available every week, it is quite possible to select those which will provide a satisfactory program; and while there are both good and bad photoplays, the good ones predominate to such an extent that the selection is an easy matter. It is also important to note that the same film is of uniform quality, regardless of whether it is shown in New York City or in a small village in some rural community; there are no second-rate companies in the movies which are sent on the road. It is important, however, to note that films should be changed at regular intervals, for the spectator's interest cannot be held by a film which he has seen before. In most towns there is a film exchange from which the films may be rented, and while the average feature commands from $50 to $100 a day when it first appears, the price eventually drops to about $10. Films may be obtained at a considerably lower cost than the last figure mentioned, but they are not of a quality which will produce the same enjoyment as films which show the work of superior talent.

* * *

SELF-ANNEALING OF BRASS

It is a familar fact that hard drawn brass when held in storage for any considerable length of time shows a decided tendency to lose its hardness or spring temper. In a few cases where the temperature has been abnormally high, these changes have come about in a comparatively short time. In many instances where brass wire had been employed because of its hardness or spring temper, it became quite useless, although it had not been in active service, but was held in storage. In some lines of work where brass springs are used, the present tendency is to discard the brass and use steel springs which do not exhibit changes due to age.

W. Arthur of the Frankford Arsenal, Philadelphia, pointed out in a paper presented at the annual meeting of the American Institute of Metals, September 11-15, in Cleveland, Ohio, that in the manufacture of cartridge cases, self-annealing and seasoning cracking must be taken into consideration. It is often necessary to store ammunition for a number of years. Any deterioration due to age becomes a matter of grave concern. Since the walls of the cartridge case must be made quite thin owing to weight requirement, it is necessary to leave them with a hard drawn temper. The internal pressure to which they are subjected is very great. The necks of the cases must hold the bullet securely, and the head must not allow the primer to loosen. Any expansion of the case in firing would probably result in its sticking in the chamber of the gun. In the case of machine guns this is a serious matter.

Illustrations were shown of cartridge cases that had cracked while in storage; in one case, the head had cracked off entirely, while in another a longitudinal crack extended from the head one-third the length of the case. The significance of seasoning cracking and self-annealing is serious, and it should receive the best attention of metallurgists. It is to be hoped that the near future will bring forth data that will enable users of brass who have difficulties of this sort to cope with them more intelligently.

* * *

Electrochemical and electrometallurgical products enter into almost every phase of our industrial life, and their manufacture has been increasing by leaps and bounds. The chief products made by the aid of the electric current are aluminum, phosphorus, silicon, sodium, graphite, chlorine, oxygen, hydrogen, ferro-alloys, copper, titanium, vanadium and other alloys, calcium carbide, carborundum and other abrasives, caustic soda, caustic potash, sodium, peroxide, chloride of lime or bleaching powder, carbon bisulphide and muriatic acid. According to a report issued by the United States Bureau of Census, the value of electrochemical products has increased from $18,450,000 in 1909 to $29,600,000 in 1914, an increase of over $11,000,000. This does not include iron and steel made in the electric furnace, which also falls under this class. The extent to which we are dependent on electrochemical products is little realized. The manufacture of these products has been steadily increasing, but today the supply is far short of the demand, due in many instances to the inability to obtain permission from the government to use more power at Niagara Falls, the great electrochemical center. Of thirty-six establishments reporting in 1914 the manufacture of electrochemical products, eighteen were located in New York, four in Michigan, three in California, two each in Pennsylvania and West Virginia, and one each in several other states. Most of the plants in New York state are at or near Niagara Falls.

TABULATED TOOL DRAWINGS

SYSTEM OF MAKING DRAWINGS OF TOOLS AND KEEPING RECORDS OF TOOLS MADE

BY C. A. KUHN*

IN all large factories doing considerable tool work, as in the automobile line, there are many tool drawings which are of similar design but of varying dimensions. These tool drawings are principally of small tools, such as reamers, taps, arbors, gages, etc. Various methods are in use to prevent a duplication of drawings and at the same time provide the shop with adequate information for manufacturing the tools. One of the most simple of these in common use is to have a large sheet, showing at the top a drawing of the tool wanted, with letters designating the various dimensions, as shown in Fig. 1. The tabulations are filled in with all the necessary dimensions and give complete information as to sizes; then, when an order is issued for any tool shown on the drawing, sent to the tool-room as a working drawing. The confusion caused by the use of the previously mentioned system is eliminated when this method is used, but the other disadvantages remain, with the additional fault that mistakes are likely to be made in copying the entries on the print. These could be prevented, of course, by checking, but this entails additional work. Again, on some of the tools it is necessary to note an exceptional treatment, such as hardening, grinding, polishing, etc. To mark this on the master sheet would require a footnote or something similar. In making out the blocked-in prints, these notes are sometimes ignored, resulting in an incorrect tool. Another drawback to the system is that it is necessary to search for a desired entry, owing to the fact that

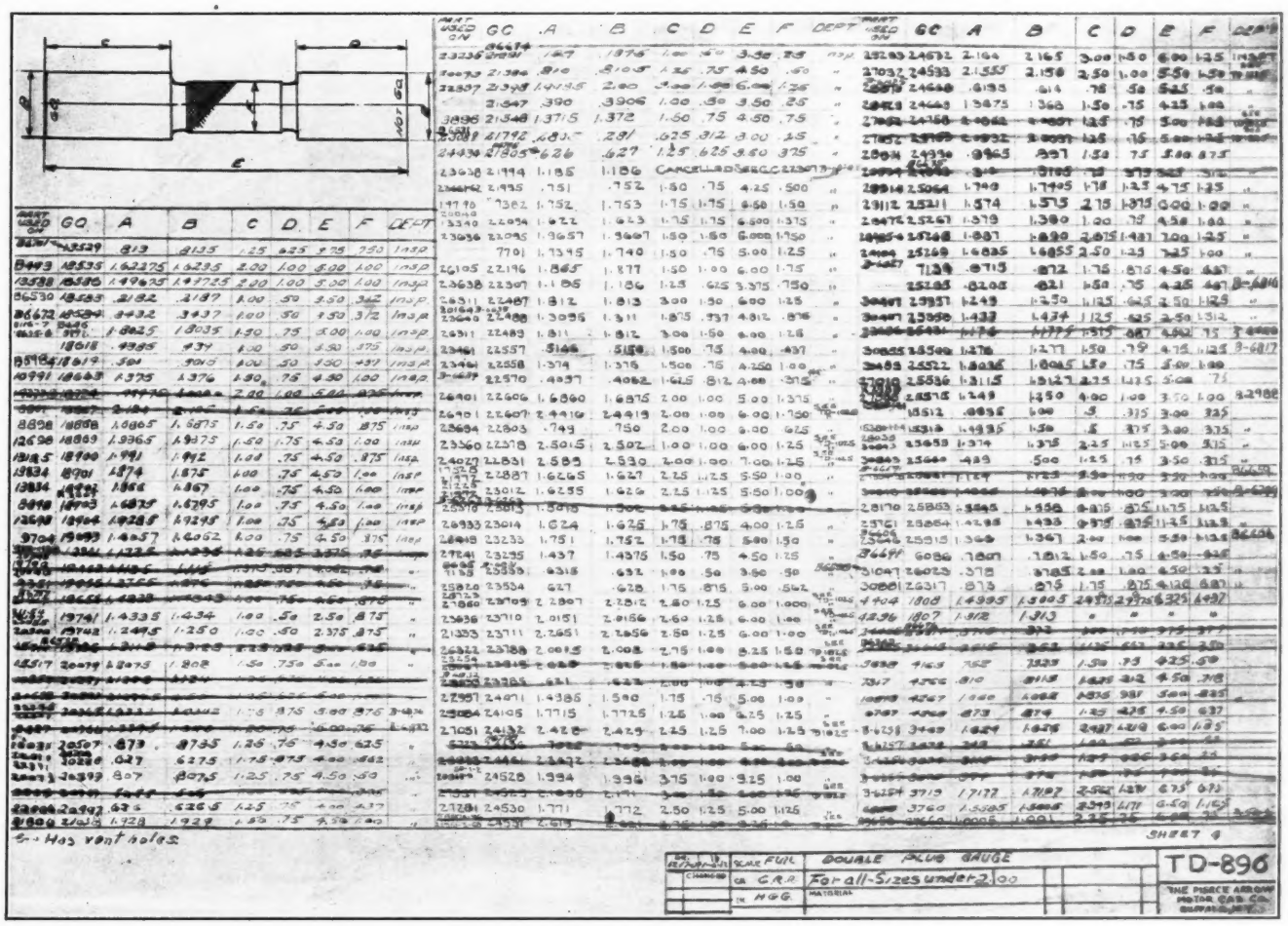


Fig. 1. Tabulated Drawing for Limit Plug Gage

the entire sheet is blueprinted and all entries are crossed out except those required.

This method, however, has its disadvantages, one of which is that in a short time the sheet becomes so crowded with figures that a draftsman, in looking it over, may pass by the dimension wanted and make an additional entry through failure to note the original. Another difficulty is that a draftsman cannot picture in his mind's eye just how the tool will look when completed. This is a serious fault, which has resulted in several freakish and unworkable tools being made. The tabulations also confuse the toolmakers and are objectionable to most of them.

Another system in vogue is to use the master tabulated sheet shown in Fig. 1 in the tool designing department only, and a blocked-in blueprint in the tool-room. Then when an order is issued for the tool-room, the various dimensions are copied from the master tabulated sheet and entered on the corresponding blank spaces shown in Fig. 2. This print is then the entries are recorded in the order of issuing them and not according to size, which is obviously the information needed by the drafting-room in looking up data for any new work.

In order to eliminate all the objections and at the same time maintain a correct record of tools of this kind, the following system has been established in one of the country's largest automobile factories with good results. An individual tracing, as shown in Fig. 3, is made of each tool, and although this may seem unnecessary, it is really not as big a proposition as it appears, as most of the drawings are very simple. In the lower right-hand corner above the drawing number of the individual sheet, the number of the master sheet is recorded. The important dimensions (which are usually the diameter or length), as well as the number of the individual drawing and the distinguishing mark of the tool, are entered on a slip of paper and placed in a Rand visible file (see Fig. 4), which is used as a permanent record.

The construction of the panel units in this file is such that the celluloid tubes can be readily moved about and replaced

* Chief Tool Designer, Pierce-Arrow Motor Car Co., Buffalo, N. Y.

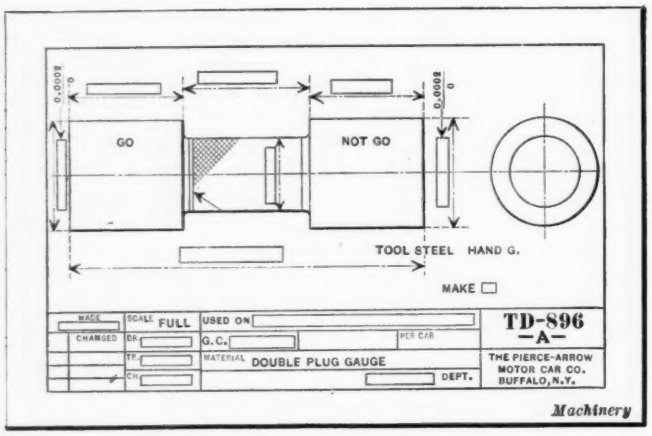


Fig. 2. Common Type of Blocked-in Drawing for Use in Shop

or removed entirely, as desired. The units used are hung on rings erected on a central standard. These rings have a number of holes in which the hinges of the panel units swing. The rings can be changed and larger ones substituted, so that more panels can be used when necessary, and expansion can thus be readily taken care of as the index grows. The file at present consists of forty sheets, in connection with the standard for the index. The method of making the entries is extremely simple, as they can be made in less than a minute on the typewriter and are easily read. The slips are filed in order of size, so that any entries can be found in a minimum amount of time. Should an entry be cancelled, it is a slight matter to remove the slip and advance all remaining entries to fill the vacant space. This system works out very satisfactorily without having any of the disadvantages incident to the method mentioned in the foregoing, and being capable of expansion, it may be continued indefinitely.

Doubtless the writer may be criticized to some extent for advocating a separate drawing for each piece of work; in defense of this, the following statement is made. It has been found by experience that in order to have tools made that are suitable for manufacturing a certain part, it is necessary for the draftsman to make an individual drawing of each, in order to obtain the correct proportions. This necessitates at least a pencil drawing to scale, from which the dimensions may be transferred to the master sheet. To make a tracing of this tool drawing does not require more than an hour or so. In a factory the size of the one using the system referred to, the number of orders for these so-called tabulated tools is so large that the amount of time consumed in entering the dimensions on a blocked-in print would soon be considerably greater than that required to make a tracing. These tracings are checked and placed in a file so that they can always be used for reference. There is also an added advantage if some existing tool is to be used, as this can be easily determined by reference to the tracing. This is more apparent on manufacturing than on inspecting tools, but as the system mentioned covers 106 different types, something equally satisfactory for all must be used, which requirements are filled by this system.

* * *

Parts of machines that are under bending stress when in use and that must fit adjacent parts, should be fitted when possible under the same conditions as when in use. For instance, the tool clapper of a planer, though usually a heavy cast-iron block, is appreciably distorted when the four clamping bolts are set up tightly on a tool. If the clapper were made to fit closely in the box with no stress on the clamping bolts it would probably stick when a tool was fixed in place. Hence the desirability of first clamping a piece firmly on the clapper before scraping the sides.

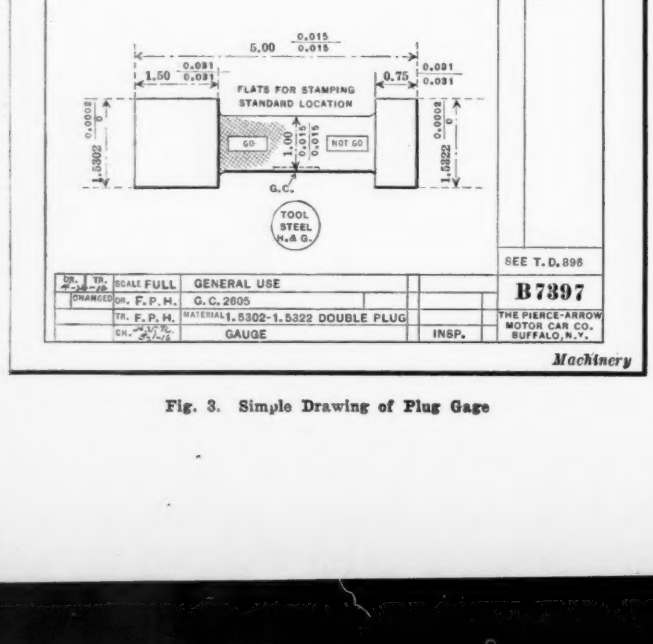


Fig. 3. Simple Drawing of Plug Gage

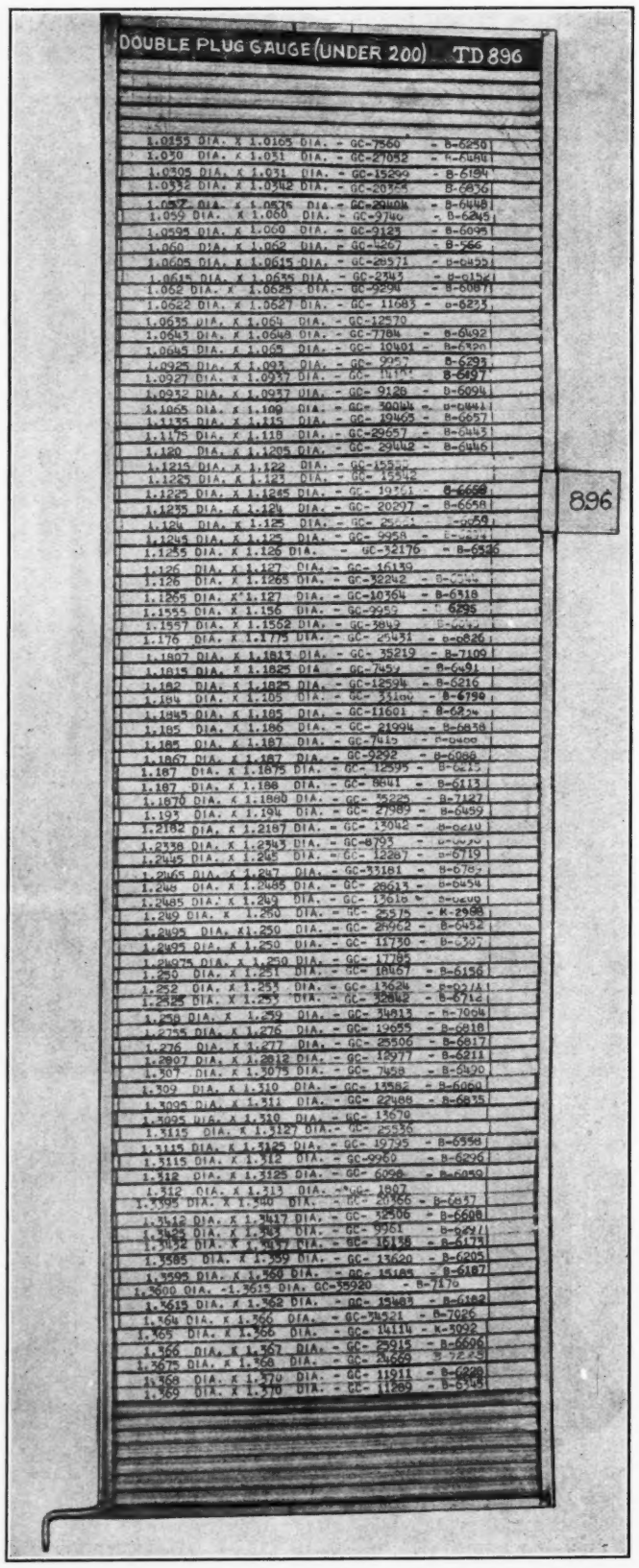


Fig. 4. One Unit of Permanent Filing System used for Tool Work

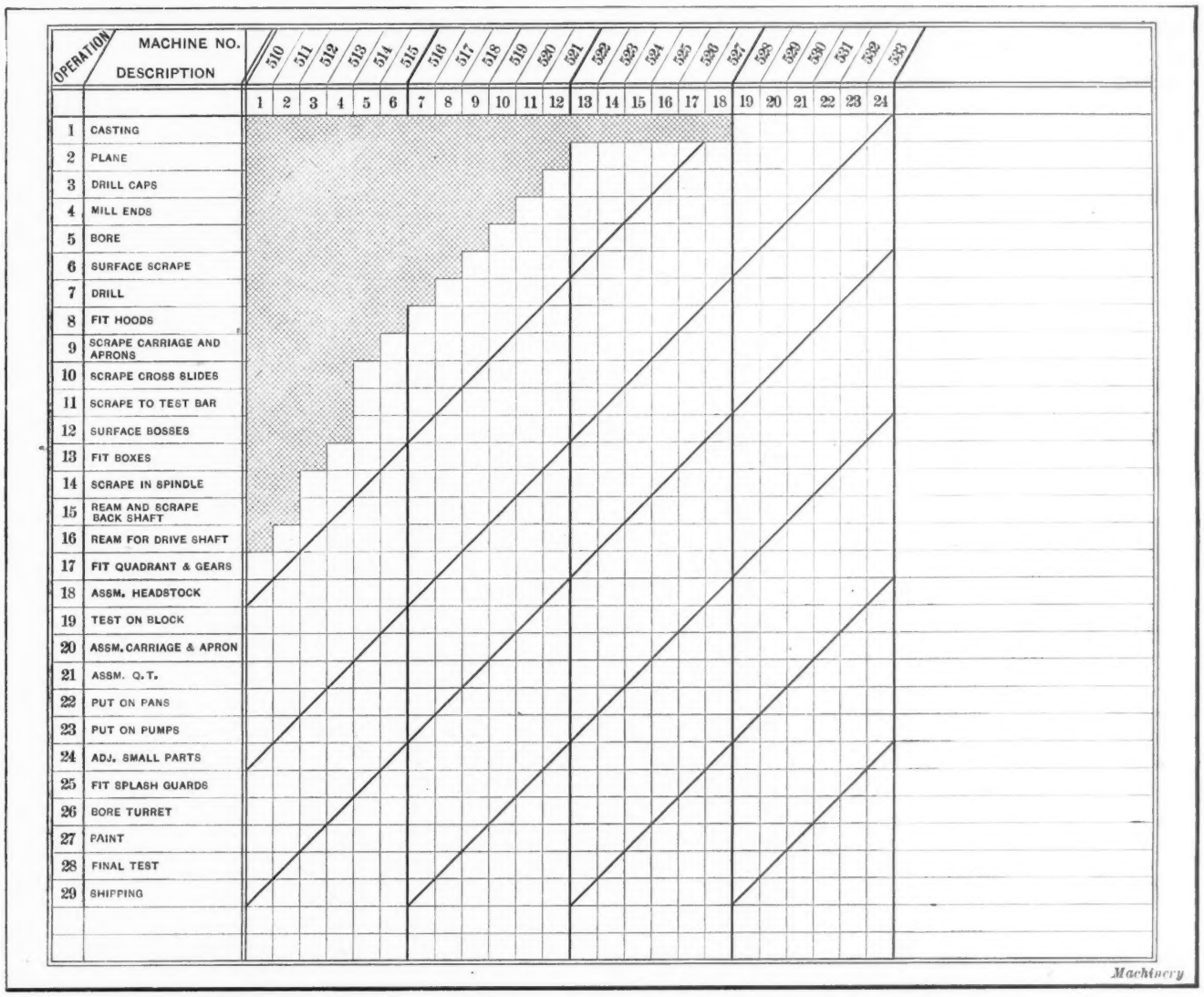
MACHINE TOOL BUILDING CHART

There are several ways of keeping track of the conditions of production in the shop when building machines in lots. But no matter how good a system is employed, it is desirable to have some graphic means of showing the daily progress to the superintendent or general manager. The board or chart that shows graphically progress and delays from day to day of operations acts as a spur on the manager, who, in turn, is likely to stimulate the activity of the men and thus bring the lagging work up to date.

The accompanying chart shows the plan of a large blackboard installed in the office of C. L. Libby, superintendent of the International Machine Tool Co., Indianapolis, Ind., to facilitate the production of the Libby turret lathes. At the left of the chart are the principal operations arranged substantially in the order in which they are generally done. These consist of casting, planing, drilling caps, milling ends, boring, surface scraping, drilling, fitting hood, scraping carriage and apron, scraping cross-slide, scraping to test bar, surfacing ten have been milled on the ends, nine have been bored, and so on. If one of the castings develops serious defects after being planed, drilled, milled or bored, it is rejected and the space on the casting line is erased until a new casting has been obtained to fill its place.

It will be noticed that the last operation that has been filled in is No. 16, "reaming for the drive-shaft," and this has been done on one machine only. No operations have been completed on the succeeding line. The general contour of the filled-in spaces approximates that of a 45-degree right-angle triangle. When the operations go through practically in the order planned and everything follows without serious hitch, this plan of progression is carried on throughout. In other words, the operations completed will be about in the order indicated by the diagonal line, and as the operations on a lot are completed they flow off the sheet at the lower right-hand corner, shipping being, of course, the last job.

Mr. Libby posts himself each day on the conditions of work in the plant, then returns to his office and with chalk fills in the squares of the operations completed. By this operation,


OPERATION
MACHINE NO.
DESCRIPTION
510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
1 CASTING
2 PLANE
3 DRILL CAPS
4 MILL ENDS
5 BORE
6 SURFACE SCRAPE
7 DRILL
8 FIT HOODS
9 SCRAPE CARRIAGE AND APRONS
10 SCRAPE CROSS SLIDES
11 SCRAPE TO TEST BAR
12 SURFACE BOSSES
13 FIT BOXES
14 SCRAPE IN SPINDLE
15 REAM AND SCRAPE BACK SHAFT
16 REAM FOR DRIVE SHAFT
17 FIT QUADRANT & GEARS
18 ASSM. HEADSTOCK
19 TEST ON BLOCK
20 ASSM. CARRIAGE & APRON
21 ASSM. Q. T.
22 PUT ON PANS
23 PUT ON PUMPS
24 ADJ. SMALL PARTS
25 FIT SPLASH GUARDS
26 BORE TURRET
27 PAINT
28 FINAL TEST
29 SHIPPING
Machinery

Production Chart used by International Machine Tool Co. to record Progress in building Machine Tools

bosses, fitting boxes, scraping in spindles, reaming and scraping back-shaft, reaming for drive-shaft, fitting quadrant and gears, assembling headstock, testing on block, assembling carriage and apron, assembling turret, putting on pan, putting on pump, adjusting small parts, fitting splash guard, boring turret, painting, final testing, and shipping. At the top are the serial numbers of the turret lathes being put through.

Now suppose that a lot of twenty-four lathes is going through the shop. The first action is getting the castings from the foundry, and the chart shows that eighteen castings have been delivered, eighteen of the squares of the chart having been chalked in. The chart also shows that twelve of the castings have been planed, eleven have been drilled for the cap-screws, he impresses on his mind the condition of work in the plant and at the same time makes a record for reference during the day. The record also acts as an incentive to everyone connected with the production department; when one of the foremen comes into the general manager's office and sees the conditions of the chart wherever his department is concerned, he is likely to spurt up if that section shows perceptible lagging behind the general ideal contour of the operation sheet.

Another feature of the management of the International Machine Tool Co.'s plant is a shop "thermometer" placed over the gallery in the machine shop where it can be seen by all. This thermometer registers the monthly production and indicates the possible bonus to be earned. The average produc-

tion of machines is between twenty-five and thirty monthly. Should the production for three months average thirty a month, or ninety for the thirteen weeks, the shop bonus would be $4000. It drops quickly to $1600 when the production falls to seventy-eight.

The shop bonus plan stimulates cooperative work; instead of some of the heads of departments being at sword's points and trying to "do" one another, they feel that they must work for the common good if the shop is to earn the highest possible bonus in the three months' period.

* * *

URANIUM HIGH-SPEED STEEL TESTS

The Standard Alloys Co. of Pittsburg, Pa., has submitted tests of uranium high-speed steel lathe tools made under the direction of the Standard Chemical Co. on a commercial scale in a number of large shops in the Pittsburg district. The effect of uranium in high-speed steel alloys is claimed to be a remarkable increase in cutting efficiency and durability. The following report of tests of uranium high-speed steel in comparison with regular high-speed steel in common use is given below. The tools marked A, B, C and D are made of regular high-speed steel, while those marked Ua, Ul, U2, etc., are made of uranium high-speed steel. The regular high-speed steel tools were all made from the larger sizes of bars, while the largest uranium tool measured only 1 by 2 inches.

Tool Symbol	Feed, in Inches	Speed, Feet per Minute	Depth of Cut, in Inches	Length Turned before Grinding Tool, in Inches
Material, Locomotive Axle, 0.40 Per Cent Carbon				
Ua	3/32	103	3/8	5
A	3/32	103	3/8	2
Material, Locomotive Crankpin, 0.40 Per Cent Carbon				
Ua	1/16	74	5/8	12
A	1/16	74	5/8	2
Ua	1/16	64	5/8	8
A	1/16	64	5/8	2
Material, 12-inch Shaft, 0.50 Per Cent Carbon				
Ul	1/16	75	1/4	17
B	1/16	75	1/4	4
D	1/16	75	1/4	1
Material, 8-inch Shaft, 0.40 Per Cent Carbon, 89 Inches Long				
Ul	1/16	51	5/8	178[1]
C	1/16	35	5/8	7/8
Material, 6-inch Shaft, 0.40 Per Cent Carbon				
Ul	1/32	75	5/8	18
U2	1/32	75	5/8	24[2]
B	1/32	75	5/8	11
Material, 10-inch Shaft, 0.40 Per Cent Carbon				
U4	1/16	60 to 65	5/8	8
U2	1/16	65	5/8	7 1/2[3]
Material, 12-inch Shaft, 0.40 Per Cent Carbon				
Ul	3/64	55	5/16	16
U5	3/64	55	5/16	15
B	3/64	55	5/16	2 1/2
Material, 12-inch Forging, 0.40 Per Cent Carbon				
U8	1/16	45	5/8 to 3/4	87[4]
U8	1/16 to 1/10	38	15/16	127[5]
U8	1/16	60	1 1/16	12

The uranium high-speed steels used in the foregoing tests have a uranium content ranging up to 1.02 per cent.

* * *

It has been estimated that a tunnel under the English Channel can be constructed for $80,000,000. Its advocates claim that of the 2,000,000 passengers who crossed the channel in both directions during the year, at least 65 per cent, or about 1,300,000 would use the tunnel. So if each were charged 10s. ($2.40), the income from this source would be $3,120,000 a year. Adding to this $325,000 for the transportation of baggage, $200,000 for postal service, and $4,000,000 for freight traffic, the total revenue would be $7,645,000. Allowing for running expenses $2,000,000 per annum, this would leave $5,645,000 as the annual net earnings.

[1] The tool was run over the shaft twice and the depth was changed to ⅝ inch on the second cut.
[2] Speed increased to 90 feet per minute after cutting 13 inches; ran 11 inches further without breaking down.
[3] The speed was increased to 80 feet per minute after running 4 inches, and the tool traveled 3½ inches further before breaking down.
[4] The tool was working most of the time with the nose in scale.
[5] The cutting time was three hours, and after cutting 105 inches the speed was increased to 65 feet per minute. The tool continued to cut for 22 inches before breaking down.

GRADUATING ON THE GEAR SHAPER

The fact that the Fellows gear shaper built by the Fellows Gear Shaper Co., Springfield, Vt., may be used effectively for graduating circles is not generally known, and the practice of the Cleveland Machine Tool Co., Cleveland, Ohio, which uses a Fellows gear shaper for graduating the circles of the circular attachment provided for the Cleveland horizontal boring machine, will be of general interest.

Fig. 1 shows a regular Fellows gear shaper set up for graduating the periphery of a 30-inch Cleveland circular table. The graduation marks required are three in number, a full line

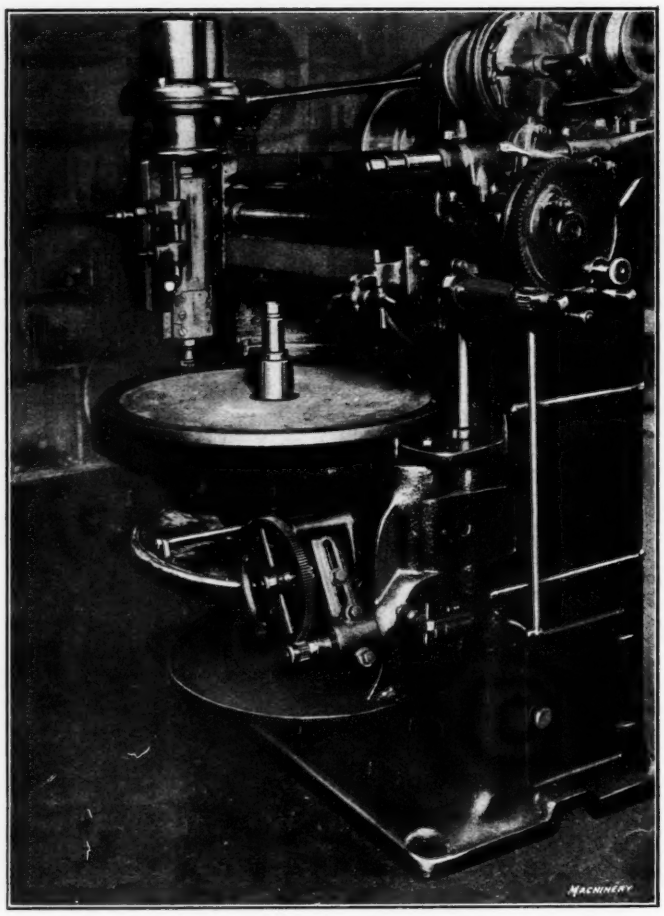


Fig. 1. Graduating Circular Table with a Fellows Gear Shaper

being used for the degree markings, which are designated 0, 5, 10, 15, 20, 25, etc.; the intermediate degrees are marked with shorter lines, while the half degrees are marked with still shorter lines.

Fig. 2 shows the cutter used for graduating. For this case the cutter is made with forty teeth and has a diameter of 1.667 inch. The diameter of the table to be graduated is 30 inches, the ratio of the two diameters being as 1 to 18. The number of graduations required on the periphery is 720; therefore, the graduating cutter must be geared to rotate eighteen times while the work revolves once. Fig. 2 shows how the cutter is made: the long lines for the degrees marked 0, 5, 10, 15, etc., extend clear to the end of the cutter; the intermediate degree line teeth are ground off so that the length cut is about two-thirds of that of the marked degrees, while the half degrees are ground back still further.

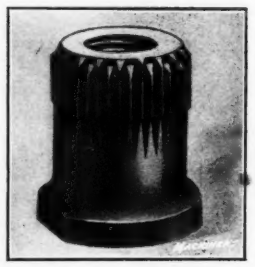
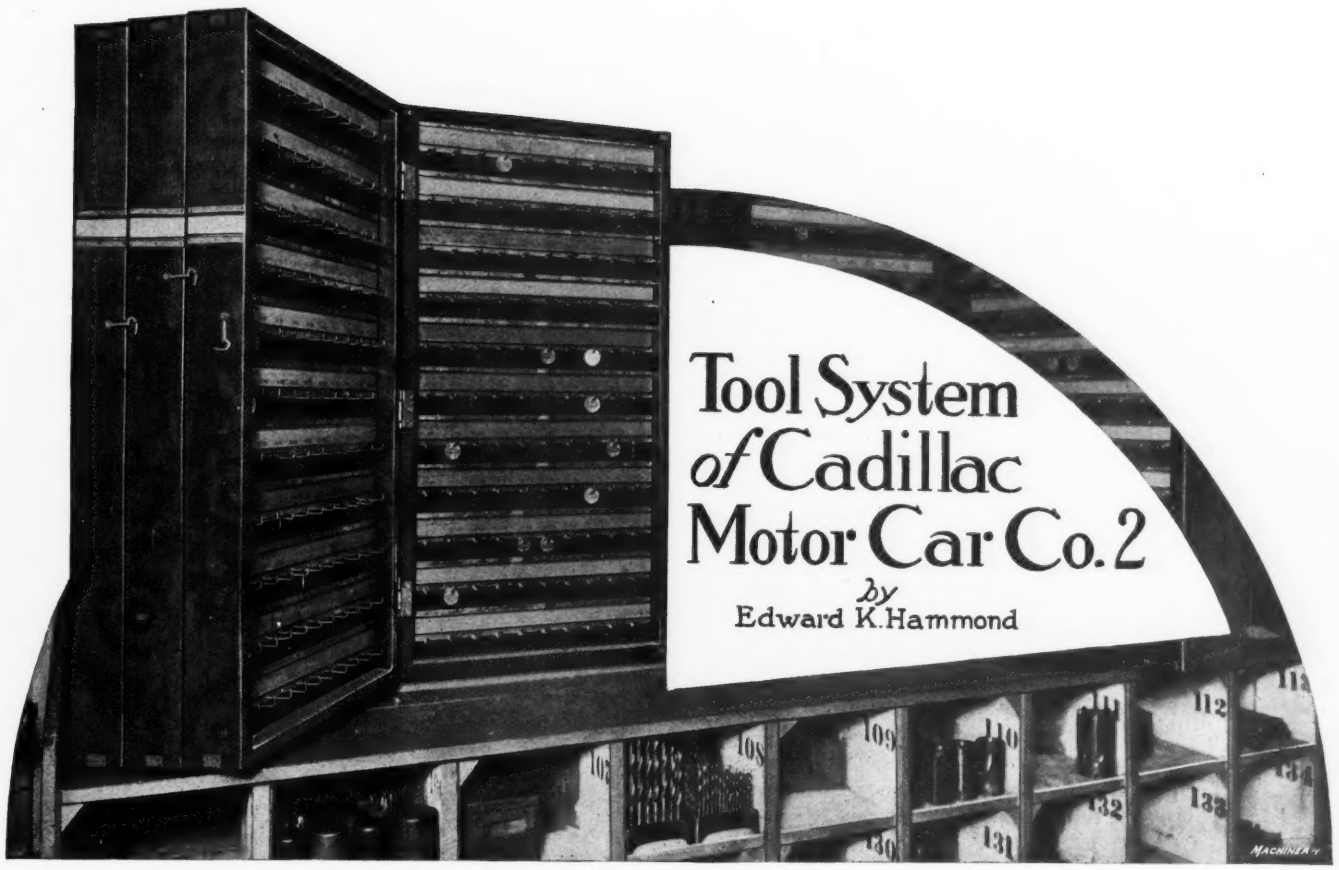


Fig. 2. Cutter used for graduating on Shaper

In operation, the cutter works exactly the same as though cutting teeth, except that no tooth curves are generated. The teeth in the cutter are sharp vees, and the depth of cut, of course, is only a few thousandths inch. This method of graduating circles is efficient, the time being only about one-fourth that required when cutting the same graduation on a milling machine. Moreover, the operation is automatic, practically no attendance being required.



Tool System of Cadillac Motor Car Co. 2

by Edward K. Hammond

IN dealing with the ordering, making, distributing and accounting of all such special tools as jigs and fixtures, the problem of the maintenance supplies and tool service department is somewhat different from that encountered in handling standard commercial tools, although the basic problem is the same. As in the case of commercial tools, the point of primary importance is to see that all shops are kept supplied with the tools which they require without any delay in delivery. What was said in regard to the work of the department in handling standard tools applies equally to the work of dealing with special tools, in so far as commercial considerations are concerned. It is obvious that the work of the department must be carried on along the most economical lines, and that careful records must be kept of all tools to see that they are not lost or damaged while in use. The chief distinction between the work of the maintenance supplies and tool service department in handling special tools and commercial tools is that the former is largely a problem of toolmaking, while the latter is a question of purchasing tools under the most advantageous terms. The following article outlines the work of the department in the ordering, making, distributing and accounting of special tools.

The first installment of this article appeared in the June, 1916, number of MACHINERY.

In order to explain the operation of the system which is used, it will doubtless be the best plan to start from the point where the engineering department has approved the design of a part for an automobile of a new model, and has authorized the making of tools for use in its manufacture. The authorization of the engineering department for the making of all special tools is issued on one of the forms reproduced in Fig. 2. One copy is sent to the office of the tool engineer, accompanied by a set of drawings of the new car part, and it is his work to design all special tools which will be required in manufacturing this part. The first step taken by the tool engineer is to compare the new part with the car part which it supersedes, in order that use may be made of any special tools by making certain changes in their construction. The points governing the decision as to whether old tools are to be made over or whether it is necessary to design entirely new tools for the purpose are details of the work of the tool engineer which do not properly come within the scope of the present article.

In any case a complete set of tool drawings will be made, the method of procedure being for the tool engineer to study the part to be machined, decide upon the methods of machining to employ, and then make rough sketches of the tools which are followed

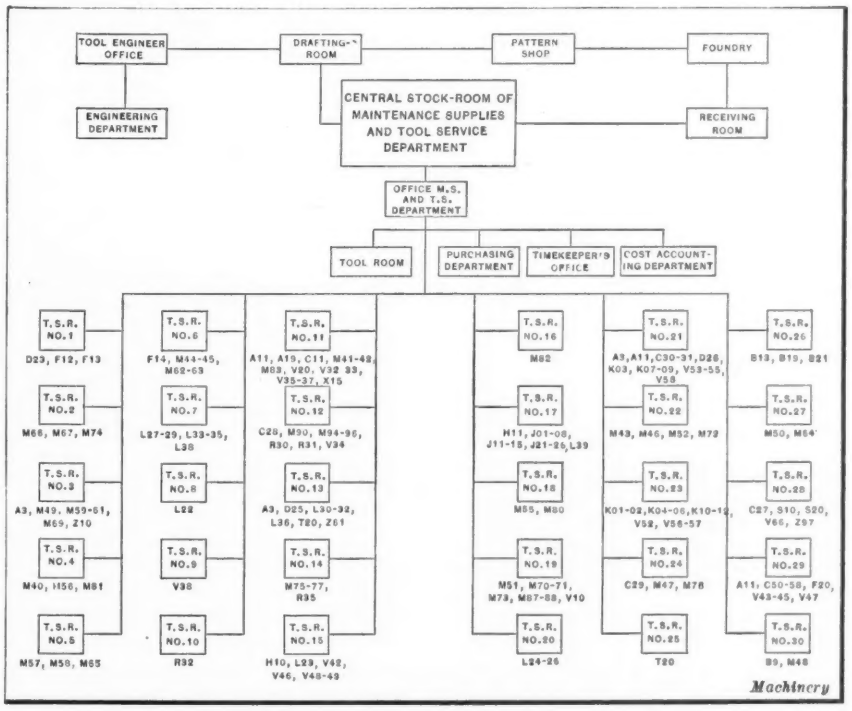
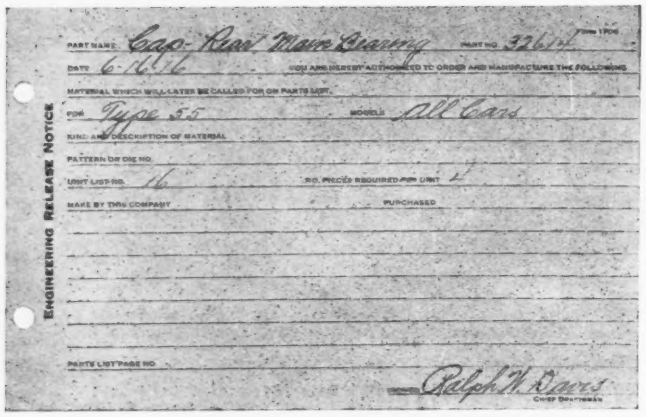

TOOL ENGINEER OFFICE
DRAFTING-ROOM
PATTERN SHOP
FOUNDRY
ENGINEERING DEPARTMENT
CENTRAL STOCK-ROOM OF MAINTENANCE SUPPLIES AND TOOL SERVICE DEPARTMENT
RECEIVING ROOM
OFFICE M.S. AND T.S. DEPARTMENT
TOOL ROOM
PURCHASING DEPARTMENT
TIMEKEEPER'S OFFICE
COST ACCOUNTING DEPARTMENT
T.S.R. NO.1 D23, F12, F13
T.S.R. NO.2 M66, M67, M74
T.S.R. NO.3 A3, M49, M59-61, M69, Z10
T.S.R. NO.4 M40, H56, M81
T.S.R. NO.5 M57, M58, M65
T.S.R. NO.6 F14, M44-45, M62-63
T.S.R. NO.7 L27-29, L33-35, L38
T.S.R. NO.8 L22
T.S.R. NO.9 V38
T.S.R. NO.10 R32
T.S.R. NO.11 A11, A19, C11, M41-42, M63, V20, V32 33, V35-37, X15
T.S.R. NO.12 C28, M90, M94-96, R30, R31, V34
T.S.R. NO.13 A3, D25, L30-32, L36, T20, Z61
T.S.R. NO.14 M75-77, R35
T.S.R. NO.15 H10, L29, V42, V46, V48-49
T.S.R. NO.16 M82
T.S.R. NO.17 H11, J01-08, J11-18, J21-25, L39
T.S.R. NO.18 M85, M89
T.S.R. NO.19 M51, M70-71, M73, M87-88, V10
T.S.R. NO.20 L24-26
T.S.R. NO.21 A3, A11, C30-31, D26, K03, K07-09, V53-55, V58
T.S.R. NO.22 M43, M46, M52, M72
T.S.R. NO.23 K01-02, K04-06, K10-12, V52, V56-57
T.S.R. NO.24 C29, M47, M76
T.S.R. NO.25 T20
T.S.R. NO.26 B13, B19, B21
T.S.R. NO.27 M50, M54
T.S.R. NO.28 C27, S10, S20, V66, Z07
T.S.R. NO.29 A11, C50-58, F20, V43-45, V47
T.S.R. NO.30 B9, M48
Machinery

Fig. 1. Diagram showing Relationship of Maintenance Supplies and Tool Service Department to Other Departments of Factory of Cadillac Motor Car Co.


ENGINEERING RELEASE NOTICE

PART NAME Cap-Rear Main Bearing PART NO. 32614

DATE 6-16-16 YOU ARE HEREBY AUTHORIZED TO ORDER AND MANUFACTURE THE FOLLOWING

MATERIAL WHICH WILL LATER BE CALLED FOR ON PARTS LIST.

FOR Type 55 MODELS All Cars

KIND AND DESCRIPTION OF MATERIAL

PATTERN OR DIE NO.

UNIT LIST NO. 16 NO. PIECES REQUIRED PER UNIT 2

MAKE BY THIS COMPANY PURCHASED

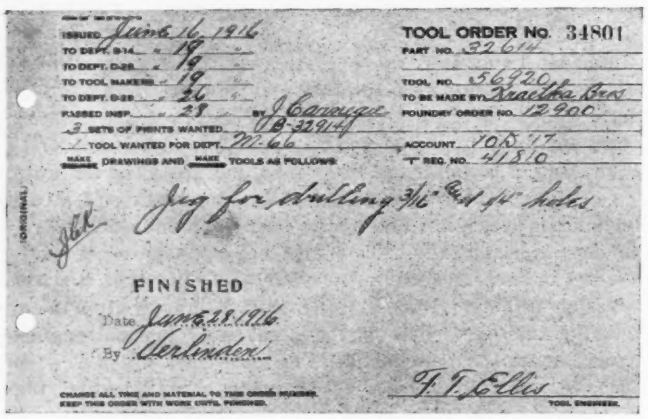
PARTS LIST PAGE NO.

Ralph H. Davis CHIEF DRAFTSMAN

Fig. 2. Form used by Engineering Department in authorizing making of Tools for Use in manufacturing Car Parts of a New Model; Size 8 by 5 Inches; One Copy on Blue Stock

by the draftsmen in making the final tool drawings. The decision as to whether new tools are to be made, or the construction of existing tools modified to meet the new requirements, will govern the procedure of the tool engineer in issuing orders for tool drawings. The form which he uses is shown in Fig. 3, and reference to this illustration will make it evident that provision is made for ordering new drawings or making changes in existing drawings by either crossing out the word "make" or "change," so that the order will meet the requirements of existing conditions.

The tool order is made out in quadruplicate. The first and second copies are sent to the drafting-room, and the first copy


ISSUED June 16 1916

TO DEPT. B-14 " 19 "

TO DEPT. D-28 " 19 "

TO TOOL MAKERS " 19 "

TO DEPT. D-28 " 26 "

PASSED INSP. " 28 " BY J Carrigue B-32914

3 SETS OF PRINTS WANTED

1 TOOL WANTED FOR DEPT. M-66

MAKE DRAWINGS AND MAKE TOOLS AS FOLLOWS

TOOL ORDER NO. 34801

PART NO. 32614

TOOL NO. 56920

TO BE MADE BY Kraetka Bros

FOUNDRY ORDER NO. 12900

ACCOUNT 10D 17

T REQ. NO. 41810

Jig for drilling 3/16" & 1/4" holes

FINISHED

Date June 28 1916

By Verlinden

F. T. Ellis TOOL ENGINEER

CHARGE ALL TIME AND MATERIAL TO THIS ORDER NUMBER. KEEP THIS ORDER WITH WORK UNTIL FINISHED.

Fig. 3. Form used by Tool Engineer in ordering Tool Drawings and Tools; Size 8 by 5 Inches; Four Copies on White, Blue, Yellow and Red Stock

remains with the work until the tools have been completed. The second copy is a drafting-room memorandum which represents the authority of this department to make the tool drawings; and after such drawings have been completed the memorandum is filed for future reference. The third copy is the tool engineer's memorandum of the transaction; this copy is kept in his "drafting-room file" until the drawings have been completed, after which it is transferred to the "tools being made file" until the work has been finished. The fourth copy of the tool order is sent to the office of the maintenance supplies and tool service department, where it is classified under the proper account; and the job is then entered on a list

OPERATION AND TOOL RECORD

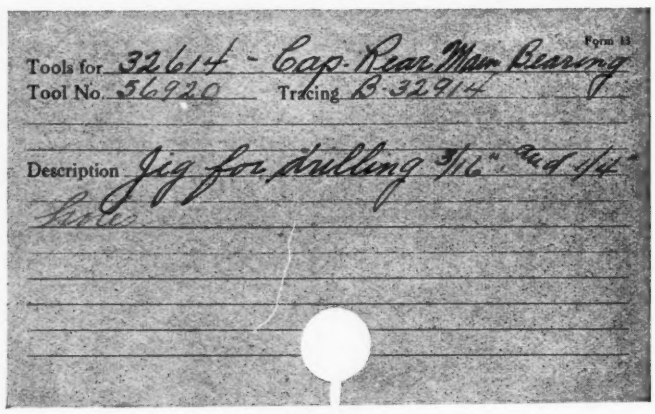
PART NAME Cap-Rear Main Bearing PART No. 32614

OPERATIONS	DRAWING NO.	DESCRIPTION OF TOOLS
1 Drilling	B-32914	Jig for drilling 3/16" & 1/4" holes

Fig. 4. Form used by Tool Engineer in maintaining Permanent Record of Machining Operations and Tools on all Car Parts; Size 10 by 8 Inches; One Copy on White Stock

of tool order numbers with their classifications, which is sent to the time office for its guidance in classifying time tickets and material orders. The fourth copy of the tool order is then sent to the foreman of the department which will make the car part that requires the use of the special tool in its manufacture, this memorandum merely serving as a notice to the foreman that his future tool requirements are being cared for.

When the tool engineer decides that a tool should either be made or changed for use in machining a certain part, and has written a tool order covering same, an entry is made on a permanent record which is kept on cards of the form shown in Fig. 4. It will be seen that this form is laid out with spaces at the top for the number of the part that the special tools are used to manufacture, and the name of this part; the part


Form 13

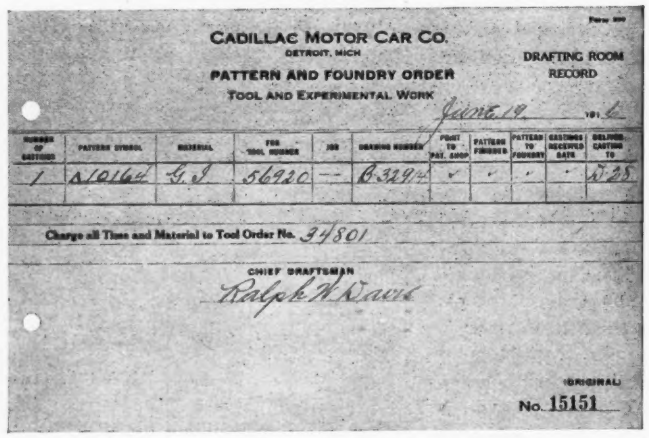
Tools for 32614 - Cap-Rear Main Bearing

Tool No. 56920 Tracing B-32914

Description Jig for drilling 3/16" and 1/4" holes

Fig. 5. Form used by Drafting-room in keeping Record of Drawings and Blueprints of Tool Drawings; Size 5 by 3 Inches; One Copy on Yellow Stock

number serves as the key by which the permanent record card is filed. The lower space on this form is laid out with sections for the operation numbers, the names of the operations, the tool order numbers on which the tools were made, the tool drawing numbers and descriptions of the tools. A brief consideration will make it evident that this card represents an outline of the machining operations performed on the part in question, and a list of all tools used in handling the work, so that by referring to this permanent record the tool engineer is able to give information in regard to all operations and tools which he has recommended for use in any given case. A similar record, though less complete than that kept by the tool


CADILLAC MOTOR CAR CO.

DETROIT, MICH

PATTERN AND FOUNDRY ORDER

TOOL AND EXPERIMENTAL WORK

DRAFTING ROOM RECORD

June 19 1916

NUMBER OF CASTINGS	PATTERN SYMBOL	MATERIAL	FOR TOOL NUMBER	JOB	DRAWING NUMBER	POINT TO PAT. SHOP	PATTERN FINISHED	PATTERN TO FOUNDRY	CASTINGS RECEIVED DATE	DELIVER CASTINGS TO
1	A1016A	G.I.	56920	--	B-32914	✓	✓	✓	✓	W.28

Charge all Time and Material to Tool Order No. 34801

CHIEF DRAFTSMAN

Ralph H. Davis

ORIGINAL

No. 15151

Fig. 6. Form used by Drafting-room in ordering Patterns and Castings; Size 8 by 5 Inches; Five Copies on Pink, Green, White, Yellow and Blue Stock

engineer, is maintained by the drafting-room for the purpose of locating the tool drawings for tools used in manufacturing any given part. At the time the first and second copies of the tool order are received in the drafting-room, a card is made out for the drafting-room file on a form shown in Fig. 5. These cards are filed by the part number, and when an inquiry is made in regard to tool drawings, this file enables the drawings to be located without delay.

Ordering Patterns and Castings

It will be obvious that the making of such special tools as jigs and fixtures will call for the use of a variety of patterns and for castings made from these patterns. Ordering these patterns and castings is part of the work of the drafting-room, the orders being issued as soon as a decision has been reached in regard to the final design of the tools. The form used by the drafting-room in ordering patterns and castings is shown in Fig. 6, five copies of this form being required. The first of these is a drafting-room copy which is kept in a temporary file until the patterns and castings have been completed, after which it is transferred to a permanent file where it is available for future reference. The second and third copies are sent to the pattern shop, and the first of these represents an order for making the patterns. The third copy is also kept in the pattern shop until the work has been completed, and at

1st COPY PURCHASING DEPT.
DATE June 19 1916 ORDER No. T 41810
ORDERED FROM Kraetha Bros
QUANTITY MATERIAL ACCOUNT
1 Jig for drilling 3/16" and 1/4" holes as per blue print F.O. 3291 Tool 56220 T.O. 34801
Casting No. 10164 to be furnished by us (Shipping order required.)
SIGNED K. D. Elmer
FORM 1788

Fig. 7. Form used by Maintenance Supplies and Tool Service Department to authorize ordering of Special Tools made by Outside Concerns; Size 8 by 5 Inches; Five Copies on Yellow, Pink, Blue, White and Green Stock

this time it is sent on to the foundry with the patterns, the form representing an order to the foundry to make the required castings. The fourth copy of the form is sent to the maintenance supplies and tool service department, where it is placed in a "current file" until the castings are received on a shipping order, after which they are delivered to the tool department. The fifth copy is sent to the tool-room, the purpose being to notify the foreman of this department that the castings have been ordered for making the tools; and as soon as the castings are received, the memorandum is destroyed.

When the necessary drawings for a tool order have been completed in the drafting-room, the first copy of the tool order,

REC'D FROM Kraetha Bros Detroit Mich. RECEIVING SLIP NO.
T-41810 DATE 6-28-16 191
PRO. NO. AM'T CHGS. WT.
NO. BOXES, PKGS., ETC. CAR INITIAL NUMBER
PURCH. ORDER | QUANTITY | PART NO. | DESCRIPTION | KEY WEIGHT
T 41810 | 1 | 32614 | Drill Jig for 3/16" hole
REMARKS:
DELIVER TO DEPT. K-28 RECEIVING DEPT.

Fig. 8. Form used by Receiving Department in recording Receipt of Tools from Outside Firms and Castings from Foundry; Size 8½ by 5 Inches; Three Copies on White Stock

Fig. 3, is returned to the tool engineer, who decides who shall make the tools called for. When a decision has been reached, he makes a notation on the order form in the space provided for that purpose and forwards the form, accompanied by two sets of blueprints of the tool drawings, to the tool order clerk in the maintenance supplies and tool service department. The tool order clerk makes an entry in a "tool order" record book by order number, and also records the blueprint in a "blueprint" record book with a notation of the tool order number. The tool order book is ruled in such a way as to provide spaces to show tool order number, tool number, date on which the order was received by the maintenance supplies and tool service department, quantity required, foundry order number, blueprint number, purchase order number if ordered from an outside firm, symbol number of car part on which tool operates, description of tool and by whom made, as well as date completed. The blueprint record book shows the sheet number of the blueprint, with all order numbers pertaining to that print.

Form 1788

NOTICE

CHARGE
ALL TIME AND MATERIAL
ON THIS TOOL TO

T. O. No. 18996

Jig, Fixtures, Punches and Dies, MUST be turned in for inspection after being machined and BEFORE bushings or dies are pressed in. All parts must be inspected before assembling, or before being hardened as the case may be.

If in doubt of any figures or details, consult foreman at once.

CADILLAC MOTOR CAR CO.

Fig. 9. Form pasted on Backs of Blueprints, constituting Order to Cadillac Tool-room to make Tools; Size 3 by 4¼ Inches; One Copy on White Stock

After the entries have been made in the tool order record book and the blueprint record book, the tool order, Fig. 3, with one complete set of blueprints, is turned over to a stenog-

C. P.-2 4-16 EXPENSE MATERIAL REQUISITION
A. 51641 DATE June 30th 1916

QUANTITY	DESCRIPTION	PRICE	EXTENSION
3	Pcs ½"×3" S M S Steel 3¼#	—	—

FOR WHAT PURPOSE USED
CHARGE TO: ORDER NO. T.O. 34801; MACH. NO.; DEPT. NO.; ACCT. NO. 105-17
DELIVER TO DEPT. NO. F 12 BIN NO. F 1246 STORE ROOM NO. D-27
BORROW J L Osgood CREDIT ACCOUNT NO. 52

Fig. 10. Form used by Tool-room Foreman in ordering Materials required for making Tools; Size 6 by 4 Inches; One Copy on Yellow Stock

rapher who writes a "T-requisition" on the purchasing department if the tool is to be ordered from an outside firm; and in all cases, the stenographer makes a complete set of record cards to be used as permanent records when the tool

Form 1273-B

TIME TICKET—NON-PRODUCTIVE

NAME Jas M Clarke NO. F 1246
DEPARTMENT NO. F-12 DATE June 20 1916

ACCOUNT NAME	FOR DEPT.	Number of Machine, Tool, S. B., Car, etc.	TIME Straight	TIME 1½	TIME Double	AMOUNT
105-17	—	T 034801	8	—	—	—

NOTE: If work is being done for another department, show number of that Dept. in column headed "For Dept."

Fig. 11. Form used by Tool-room Foreman in reporting Labor Charges on Tools to Cost Accounting Department; Size 6 by 4 Inches; One Copy on Blue Stock

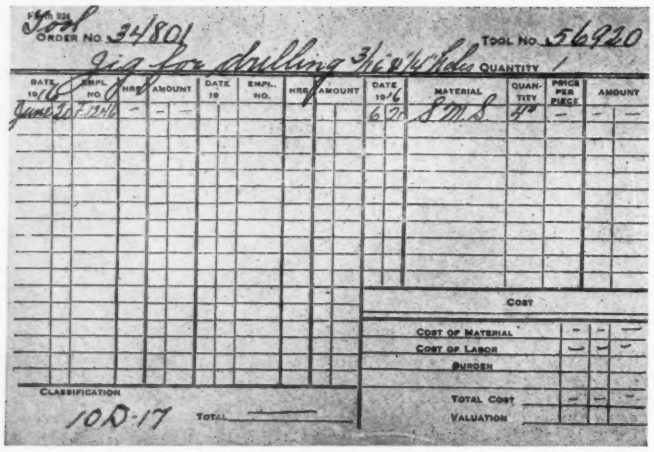


Fig. 12. Form used by Cost Accounting Department in recording Labor and Material Charges on Tools; Size 6 by 4 Inches; One Copy on Green Stock

has been completed, as outlined in detail in subsequent paragraphs. This set of record cards consists of those shown in Figs. 12, and 14 to 22. These cards, with the exception of the one shown in Fig. 12, are filed in what is known as the "shop box file" and are cross-indexed by tool and part symbol numbers, until the tool has been finished, at which time they are distributed to various permanent record files as explained later. The card shown in Fig. 12 is filed by the tool order number in what is called the "cost file," and all time, material and invoices pertaining to that particular tool order are posted thereon from time to time.

Ordering Tools Made by Outside Shops

The Cadillac Motor Car Co. has adopted the commonly used plan of having certain classes of work done by outside shops,

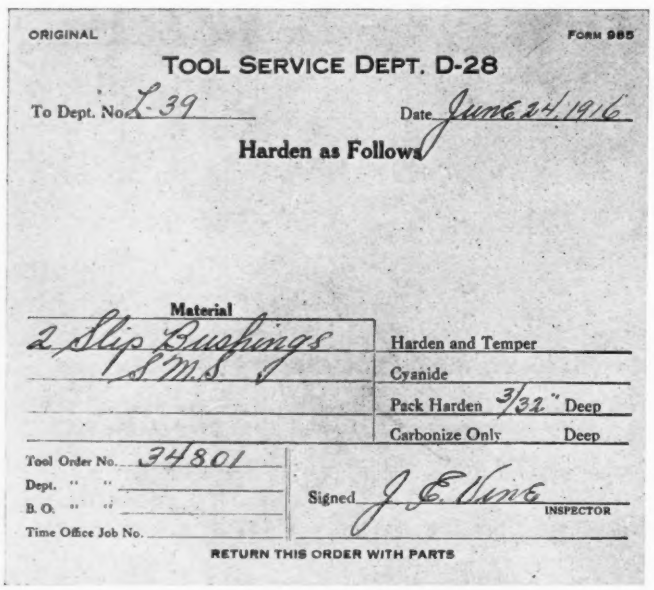


Fig. 13. Form used by Tool-room Foreman in ordering Heat-treatment of Tools; Size 6 by 5½ Inches; Three Copies on White, Pink and Blue Stock

and some of the tool work is handled in this way. The variety of cases which are dealt with naturally introduces a number of different conditions, but it frequently happens that castings for a jig or fixture will be made in the Cadillac foundry, and these castings will then be sent out for use in making the required tools. For the purpose of discussion, this condition will be assumed in describing the method of procedure which is followed. In connection with the article describing the practice in the purchase of standard commercial tools, it was mentioned that the maintenance supplies and tool service department has jurisdiction over all purchases of tools and other manufacturing supplies, the plan being for this department to make recommendations which are followed by the purchasing department in the actual issuing of orders. We will assume that it is required to order an outside firm to make a jig for drilling 3/16- and 1/4-inch holes in a given part, and that the casting for this drill jig is to be furnished by the Cadillac company. The maintenance supplies and tool service department will proceed by issuing a "T-requisition" to the purchasing department, calling upon it to order this work done, and the firm which is to do the work will be specified for the guidance of the purchasing department.

Fig. 7 shows the memorandum which is made out, and reference to this illustration will show that in addition to a description of the tool required, a notation is also made of the fact that the casting is to be furnished by the Cadillac company. Five copies of this form are required. The first is sent to the purchasing department, where it is used in issuing a regular purchasing order. The second copy is held in a "temporary file" on the desk of the tool order clerk in the maintenance supplies and tool service department, and when the order has been filled, this form is stamped "Filled," initialed

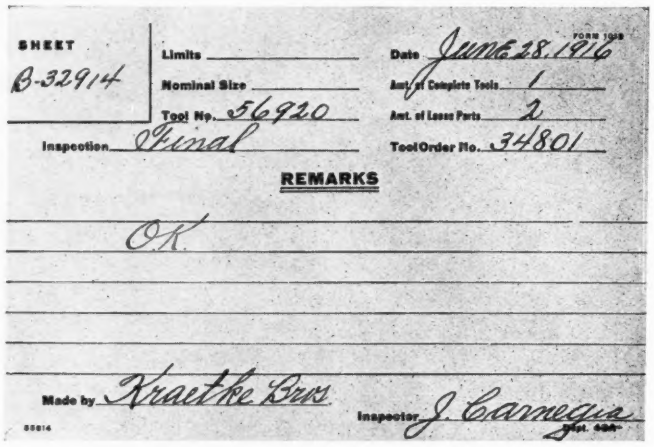


Fig. 14. Form used by Inspectors in reporting Results of Inspection of New Tools; Size 6 by 4 Inches; One Copy on White Stock

by the clerk, and filed for future reference. The third copy goes to the inspector in the maintenance supplies and tool service department to serve as a reminder that the tool is coming through and must be inspected in due course. After the inspection has been made and the tool found to be up to specifications in every way, this inspector's copy is destroyed and a permanent inspection card placed on file. The fourth copy is sent to the foreman of the department in which the tools are to be used, to serve as a further notification to him that his requirements are being cared for. The fifth copy is used by the tool "chaser" whose duty it is to follow up each order and see that it is progressing satisfactorily. When the tools are delivered to the factory, the receiving department makes out a receiving slip, using the form shown in Fig. 8, and the tools, together with this form, are sent to the inspector in the maintenance supplies and tool service department. This slip is signed and returned to the receiving room, where it serves as a receipt for the tools which have been delivered to the inspector. When the tools have been delivered, the tool

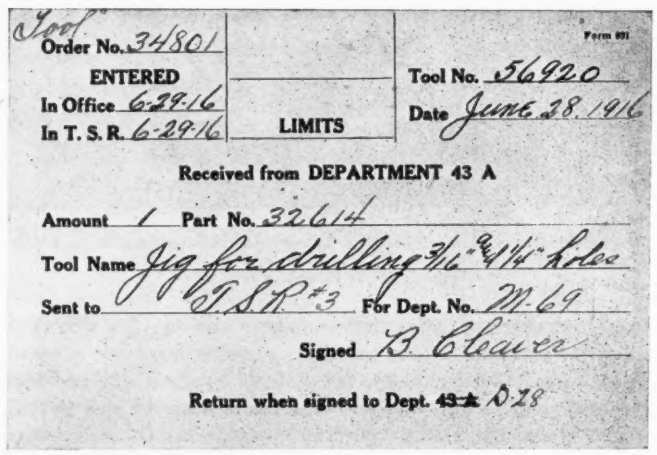

Tool
Order No. 34801
ENTERED
In Office 6-29-16
In T. S. R. 6-29-16
LIMITS
Tool No. 56920
Date June 28. 1916
Received from DEPARTMENT 43 A
Amount 1 Part No. 32614
Tool Name Jig for drilling 3/16" & 1/4" holes
Sent to T.S.R. #3 For Dept. No. M-69
Signed B Glover
Return when signed to Dept. 43-A D.28

Fig. 15. Form used by Maintenance Supplies and Tool Service Department in obtaining Receipt from Tool Supply Rooms for New Tools; Size 6 by 4 Inches; One Copy on Blue Stock

Fig. 16. Check Board Tag

chaser's interest in them ceases, and as soon as he has been assured of the fact, he can destroy his copy of the T-requisition slip.

It should be noticed that on the right-hand side of the form shown in Fig. 7, a column is provided to show the account to which the tool is to be charged, and in this column is a notation of the tool order number. This is shown for the guidance of the book-keeping department, to insure the invoice being forwarded to the maintenance supplies and tool service department to have the price O.K.'d, classified and posted on the cost card, Fig. 12, which is filed in the maintenance supplies and tool service department—by tool order number before the tool is completed, and by tool number after it has been completed.

Making Tools in Cadillac Tool-room

The description given in the preceding paragraphs refers to a case where it was decided to have the tool made by an outside firm; and it will be recalled that in issuing the order

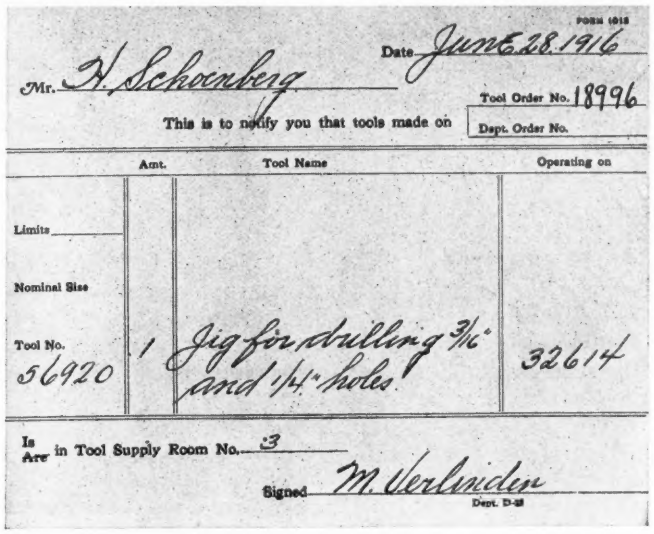


Fig. 17. Form used by Maintenance Supplies and Tool Service Department in reporting to Shop Foreman on Delivery of New Tools to his Tool Supply Room; Size 6 by 4⅞ Inches; One Copy on Blue Stock

for making the tool, the maintenance supplies and tool service department sent a "T-requisition" to the purchasing department, making use of the form shown in Fig. 7. But it does not always happen that tools are sent out to be made; in many cases the work is done in the tool-room maintained by the Cadillac Motor Car Co., and when handled in this way the method of procedure is slightly different. Instead of issuing orders to the purchasing department, as soon as the tool order and drawings have been received in its office, the maintenance supplies and tool service department proceeds by entering the proper tool order numbers on gummed labels shown in Fig. 9 and pasting one of these labels on the back of each tool drawing. The drawings are then sent out to the foreman of the tool-room, and their receipt is regarded as an order to proceed with the making of the tools. The way in which castings have been handled has already been described, and it will be assumed that the castings are available for use in the tool-room. The first copy of the tool order, Fig. 3, is sent to the tool department and kept with the work until completed, after record cards have been made by the stenographer, as previously explained.

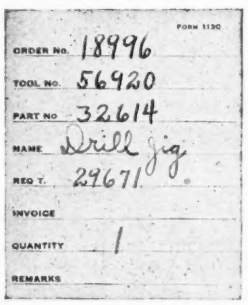


Fig. 18. Form used in reporting Completion of Tools to Cost Accounting Department

Other materials required for making the tools are ordered by the tool-room foreman on requisition slips of the form illustrated in Fig. 10. It will be seen that the requisition is dated, and that there are spaces on the form for noting the store-room

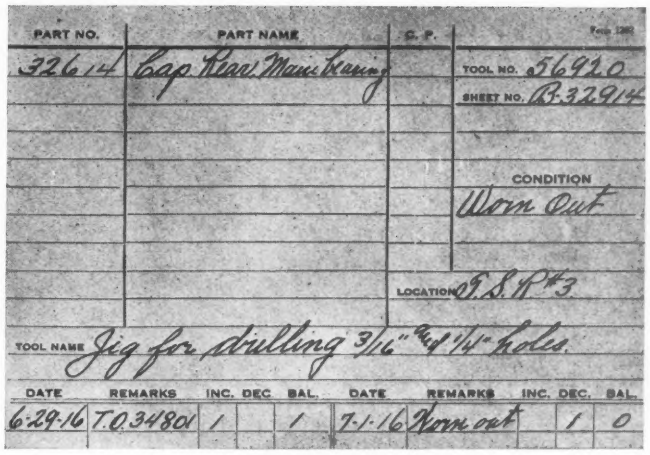


Fig. 19. Form used by Maintenance Supplies and Tool Service Department in keeping Card File of Tools by Tool Number; Size 6 by 4 Inches; One Copy on Green Stock

from which the material was drawn, the department to which it was delivered, and the accounts which are to be credited and debited, together with spaces for noting the tool order number, etc. The clock number of the man to whom the material is to be delivered is noted on the slip, which is signed by the foreman of the tool-room. These requisition slips are left in the store-rooms in exchange for the material, and at intervals of one-half hour they are gathered up by one of the messengers who make regular rounds in such a way that the slips will reach the cost accounting department in not less than one and one-half hour after they were left in the store-room. In the space at the middle of the form, notations are made as to the quantity and kind of material drawn out; the price of this material is entered on the slip by the cost accounting department, and the slip is then forwarded to the cost clerk in the maintenance supplies and tool service department, who posts them on the cost card, Fig. 12.

Reports of labor charges on tools made in the factory are also submitted to the cost clerk for use in calculating the total value of the tool. For the purpose of reporting the labor costs on each job, the foreman of the department in which the work is done turns in daily time tickets of the form shown in Fig. 11. At the top of these tickets, the names and time-

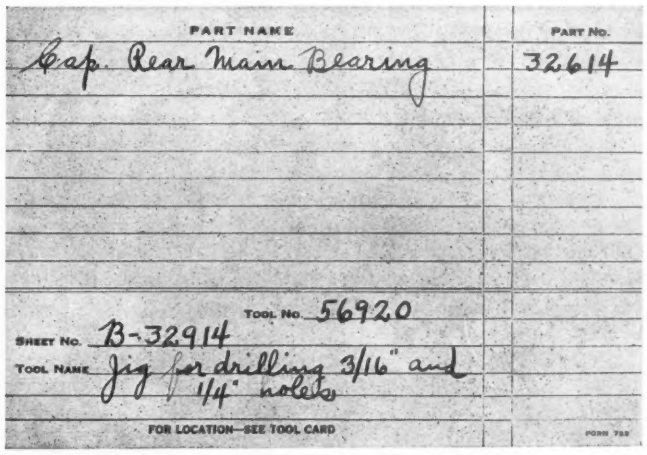


Fig. 20. Form used by Maintenance Supplies and Tool Service Department in keeping Card File of Tools by Part Number; Size 6 by 4 Inches; One Copy on Red Stock

clock numbers of the employes are recorded, together with the numbers of the departments in which they are employed and the date. In the space at the bottom of the form a record is kept of all labor costs to be charged against the tool order, and each day these time tickets are sent to the time office to be classified under their proper account, according to the list furnished by the maintenance supplies and tool service department. The rates are then extended and the slips are forwarded to the cost clerk in the maintenance supplies and tool service department, where the data are entered on the cost cards shown in Fig. 12, after which the time tickets,

Location Bin #36 Form 915
Part No. 32614 Tool No. 56920

Date	Inc.	Dec.	Bal.	Date	Inc.	Dec.	Bal.
6-29-16	1		1				
7-1-16		1	0				

T. S. R. No. 3

Fig. 21. Form used by Tool Supply Rooms in keeping Card File of Tools by Tool Number; Size 5 by 3 Inches; One Copy on Green Stock

Fig. 11, are returned to the time office. The clerk who attends to the maintenance of the cost records is under the jurisdiction of the cost accounting department, although he works in the office of the maintenance supplies and tool service department. In addition to recording labor costs in the manner referred to, it will also be evident that the costs of all materials entering into the construction of the tools are entered on this card, data for the purpose being taken from the material requisition slips shown in Fig. 10.

With these data at hand, the cost accounting clerk is able to figure the total cost and valuation of the tool. On the oppo-

Form 1540
LOCATION Bin #36 TOOL NO. 56920
PART NO. 32614
PART NAME Cap. Rear Main Bearing
TOOL NAME Jig for drilling 3/16" and 1/4" holes
SEE TOOL CARD

Fig. 22. Form used by Tool Supply Rooms in keeping File of Tools by Part Number; Size 5 by 3 Inches; One Copy on White Stock

site side of the card shown in Fig. 12, there is a form which provides for maintaining a record of the number of tools of each particular type which are on hand in the factory, and should it happen that one of these tools is worn out or broken, or if another tool of the same type is added to the supply, a notation is made to that effect so that information is available for the purpose of taking inventory. Similarly, if a tool is made outside, the invoice is forwarded from the bookkeeping department to the cost accounting department to be posted on the cost card.

TOOL SUPPLY ROOM NO. 3
Report of Special Tools for week ending July 1, 1916
Signed R. E. Chevaire

Tool No.	Part No.	Amount	Name of Tool	No. Card	Out—Card in File	Date
57334	33762	1	Milling fixture for starter bearing bolts on gear case	✓		6/28/16

Fig. 23. Form used by Tool Supply Rooms in making Weekly Reports; Size 8 by 5 Inches; One Copy on Yellow Stock

Issuing Orders for Heat-treatment of Tool Parts

When it is necessary to heat-treat parts of tools, an order must be issued for doing this work, and in issuing such orders use is made of the form shown in Fig. 13. This form is made out in triplicate, the first and second copies being sent to the hardening department with the work, and the third copy being kept in the office of the maintenance supplies and tools service department until the parts have been returned. The first copy of the memorandum is returned with the work, and the second copy filed in the heat-treating department as a record of the work done; the first and third copies of the memorandum are then destroyed. In charging heat-treatment against the cost of the tool, it will of course be evident that use is made of the time ticket shown in Fig. 11 for reporting

TOOL CHECK CARD Form 1550
CHECK No. M.6910 T. S. R. No. 3 DEPT. No. M.69

DATE	NAME	ISSUED	INCREASE	DECREASE	BALANCE
Feb. 23/916	A. Nilsen	15			15
Mar. 1 1916			5		20
June 1 1916				5	15

Fig. 24. Form used by Tool Supply Rooms in keeping Record of Workmen's Tool Checks; Size 5 by 3 Inches; One Copy on White Stock

labor charges to the cost accounting department; and the material expense requisition shown in Fig. 10 is used when ordering materials for the process of heat-treatment.

How Records of Special Tools Are Kept

When all work on the tool order has been completed, the finished tool with the first copy of the tool order, Fig. 3, and the blueprints of the tool drawings are given to the special-tool inspectors in the maintenance supplies and tool service

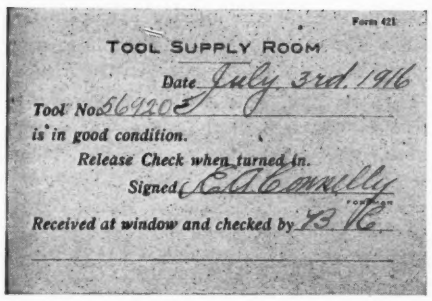
TOOL SUPPLY ROOM Form 406
Give the following Tools to Check No. M.6910
SPECIAL TOOLS (Tools with Tool Numbers)
Kind of Tool Jig for drilling 3/16" & 1/4" holes
Operating on 32614
Kind of Tool
Operating on
COMMERCIAL TOOLS (Tools without Tool Numbers)

Amt.	2	Size	3/16"	Kind	D.S.&S. drills
Amt.	2	Size	1/4"	Kind	" " "
Amt.		Size		Kind	

Signed A. Schoenberg Foreman

Fig. 25. Form used by Shop Foremen in authorizing Tool Supply Room to deliver Tools to Men; Size 5¼ by 4 Inches; One Copy on Green Stock

department. These inspectors are practical toolmakers and mechanics of wide experience, and are provided with all the latest improved tools necessary to make an exhaustive and thorough inspection of all special tools used to produce parts for Cadillac motor cars. When they have finished making the inspection, they report their findings on an inspection card, shown in Fig. 14, and pass the card, tool and drawings to the clerk whose business it is to see that the finished tool is delivered to the tool supply room connected with the department in which the tool is to be used. When this clerk receives the tool, he immediately stamps the tool order form, Fig. 3, "Completed" and gives it to the tool order clerk who records it as completed, and then forwards the form to the tool engi-


Form 421

TOOL SUPPLY ROOM

Date July 3rd. 1916

Tool No. 56920 5

is in good condition.

Release Check when turned in.

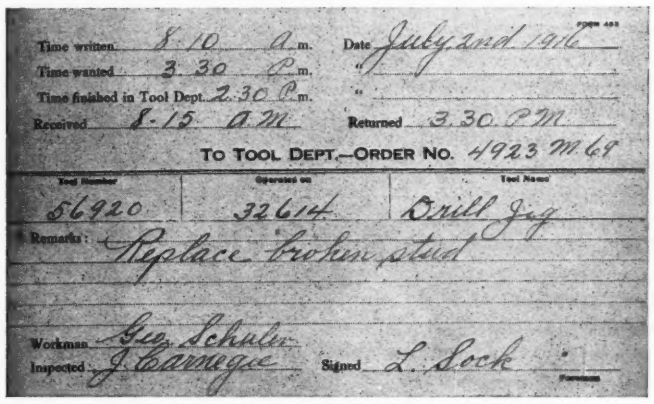
Signed E S Connelly
foreman

Received at window and checked by B M

Fig. 26. Form used by Shop Foremen in authorizing Tool Supply Room to return Checks in Exchange for Tools; Size 4 by 2⅝ Inches; One Copy on White Stock

neer. When he has disposed of the tool order, the clerk takes out the set of record cards which have been filed in the "shop box" and takes from them the card shown in Fig. 15, known as the "receipt card," also the tag shown in Fig. 16 which is used on the tool check board to indicate the hook assigned to the tool, and delivers them to the man in charge of the delivery of tools. A notice, Fig. 17, is also sent at this time to the foreman who will use the tool. The remainder of the set of cards are held on the clerk's desk until the receipt card is signed by the man in the tool supply room and returned.

When the receipt card is signed and returned, it is attached to the remainder of the sets of cards and given to the finished-


Time written 8 10 a.m. Date July 2nd 1916

Time wanted 3 30 P.m. "

Time finished in Tool Dept. 2.30 P.m. "

Received 8-15 a.m. Returned 3.30 P.M.

TO TOOL DEPT.—ORDER NO. 4923 M 69

Tool Number	Operation on	Tool Name
56920	32614	Drill Jig

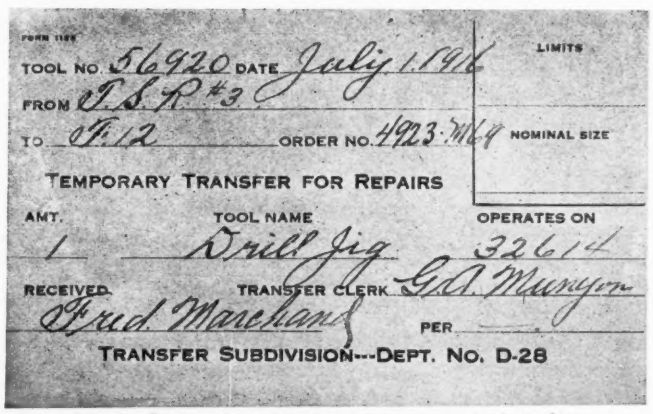
Remarks: Replace broken stud

Workman Geo Schuler

Inspected J Carnegie Signed L. Sock Foreman

Fig. 27. Form used by Shop Foremen in ordering Repair of Broken or Worn Tools; Size 7 by 4¼ Inches; One Copy on White Stock

tool record clerk, whose duty consists of taking the card shown in Fig. 18 and forwarding it to the cost clerk, which constitutes a notice that the tool has been completed and that he may close his cost card, and file it for inventory purposes. The record clerk next takes the cards shown in Figs. 19 and 20, which are known as the "tool" and "symbol" cards, respectively, and files them in separate files; the tool card is filed by the tool number and the symbol card by the symbol number of the motor part, thus constituting an effective cross-indexed file. The inspection card and the blue receipt card, Figs. 14 and 15, are filed together in a file labeled for that purpose. The cards shown in Figs. 21 and 22 are given to a clerk who makes daily trips to each of the tool supply rooms, and files them in filing cabinets for the convenience of the


FORM 1128

TOOL NO. 56920 DATE July 1. 1916 LIMITS

FROM T.S.R #3

TO T. 12 ORDER NO. 4923 M 69 NOMINAL SIZE

TEMPORARY TRANSFER FOR REPAIRS

AMT.	TOOL NAME	OPERATES ON
1	Drill Jig	32614

RECEIVED Fred. Marchand TRANSFER CLERK G.A. Munyon PER

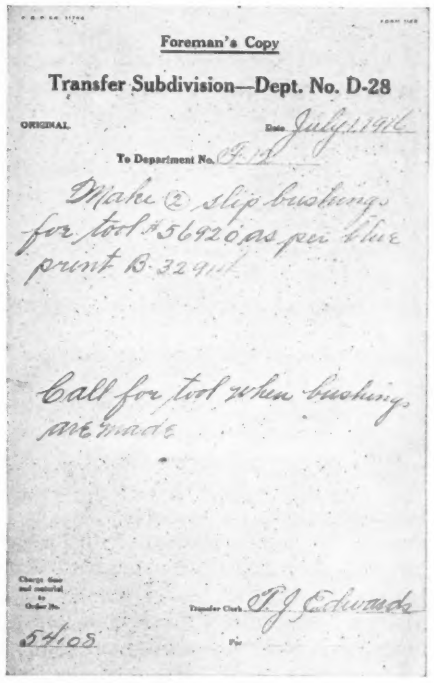
TRANSFER SUBDIVISION---DEPT. NO. D-28

Fig. 28. Form used by Tool Supply Rooms in recording Temporary Transfer of Tools for Repair; Size 5 by 3 Inches; Three Copies on Yellow, White and Salmon Stock

man in the tool supply room. When the tool was delivered to the tool supply room, an entry was made in the "incoming" record book, which is checked by the clerk who puts the cards in the tool supply room files. Also, the tag shown in Fig. 16 was placed on the check board for convenience in checking the tool to a workman; and the placing of this tag is later verified by the man in charge of maintaining the check boards and the checks in order.

Weekly Reports of Conditions in Tool Supply Rooms

It will be recalled that when the new tools were completed and sent down to the tool supply room, a receipt, Fig. 15, was obtained for them. At the same time an entry of the receipt of the tools was made in the "incoming" book which is kept in each tool supply room, and the small tag shown in Fig. 16 was hung on a hook on the check board ready for a tool check to be put over it when the tool is sent out to the shop. Then on the following day, a clerk went down to enter the tools on the card file in the tool supply room and to see that other parts of the work were properly looked after. Similarly, other entries are made in the "outgoing" book at the time that tools are sent up to the tool-room for repair or when permanent transfers of tools are made from one department to another. Once a week the tool supply room attendant examines these books in order to find out just how conditions stand. He examines both the "incoming" and "outgoing" books, and also makes sure that spaces have been provided


Foreman's Copy

Transfer Subdivision—Dept. No. D-28

ORIGINAL Date July 1 1916

To Department No. D-12

Make ② slip bushings for tool 56920 as per blue print B-32911

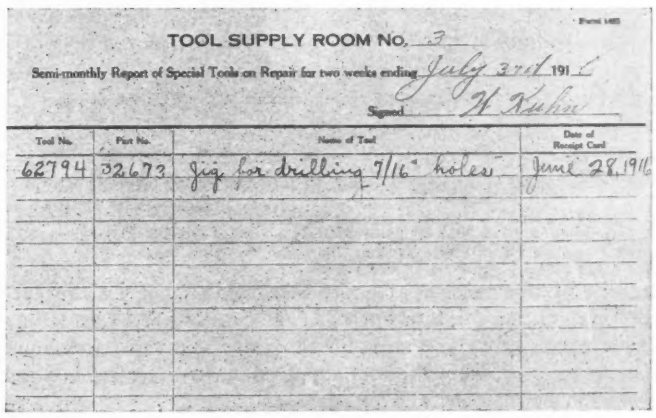
Call for tool when bushings are made

Charge time and material to Order No. 54105

Transfer Clerk P J Edwards

Per

Fig. 29. Form used by Foremen in ordering Replacement Parts for Special Tools sent for when Parts are ready to be put in Place; Size 5½ by 8½ Inches; Four Copies on White, Pink, Blue and Yellow Stock


Form 1485

TOOL SUPPLY ROOM No. 3

Semi-monthly Report of Special Tools on Repair for two weeks ending July 3rd 1916

Signed H Kuhn

Tool No.	Part No.	Name of Tool	Date of Receipt Card
62794	32673	Jig for drilling 7/16" holes	June 28.1916

Fig. 30. Form used by Tool Supply Rooms in making Semi-monthly Reports of Special Tools sent out for Repair; Size 8½ by 5¼ Inches; One Copy on Yellow Stock

on the check board for all new tools delivered to the tool supply room, and that these tools have been properly entered on the card file. The results of this inspection are entered on a form shown in Fig. 23, and the report is sent to the maintenance supplies and tool service department. In cases where any discrepancies are discovered, an investigation is immediately started to find the cause of the trouble and to take steps to correct it.

SPECIAL TOOL RELEASE — FORM 1357

FOR COST ACC'TS DEPT. ONLY
CHARGE DEPT. NO. M69
PRICE EA. | TOTAL COST
CREDIT 10D-17
CHARGE

LIMITS — DATE 7-1-16
NOMINAL SIZE — TOOL NO. 56920
TOOL NAME Drill Jig
PART NO. 32640
AMOUNT — BROKEN
AMOUNT — WORN OUT
AMOUNT
PLACE X IN ☐ OPPOSITE THE ITEM TO INDICATE CONDITION
FROM T. S. R. NO. 9
SIGNED R. M. Bacon
FOREMAN DEPT. NO. M69
DEDUCTED FROM D 28 INV. BY Schuler
" IN T. S. R. BY Mayes
" FROM COST INV. BY Carson

Fig. 31. Form used by Maintenance Supplies and Tool Service Department in sending Cost Accounting Department Data on Discarded Tools for Use in Adjustment of Accounts; Size 6 by 4½ Inches; One Copy on Dun Stock

Checking Tools Out to the Factory

We have now followed through the process of toolmaking to the point where the finished tools have been delivered to the tool supply room, regardless of whether the work was done by an outside concern or in the tool-room in the Cadillac factory. It will also be remembered that a report, Fig. 17, was sent to the foreman who will have use for the tools, advising him that they are in his tool supply room and available for use. These tools are checked out to the men against the usual form of tool checks, and for the purpose of explaining all parts of this tool system, we will assume that the new tools will first be used by an employe who has just been hired. Before this man can obtain any tools from the tool-room he must be provided with a set of tool checks, the number given him usually being fifteen. The new man is taken to the tool supply room by his foreman and supplied with checks, a

Part No. 32614 — Box No. 1428
Part Name Cap - Rear Main Bearing

Tool No.	Quantity	SPECIAL TOOLS Tool Name
56920	1	Jig for drilling 3/16" & 1/4" hole

Fig. 32. Form used by Maintenance Supplies and Tool Service Department in keeping Card File of Sets of Tools used for Specified Operations; Size 6 by 4 Inches; One Copy on White Stock

record of the number given to him being made on the card file maintained for this purpose. The cards are ruled with a form which provides spaces for the name and time clock number of the workman, the tool supply room number from which he will obtain tools, and the department number in which he is employed. One of these cards is shown in Fig. 24, and it will be seen that at the right-hand side spaces are provided for recording the number of checks with which the workman is provided. From time to time, special conditions may make it necessary for a man to have more checks given him; and, in other cases, the number of checks which he has may be reduced. In either case, the addition or deduction is noted on the form, and the balance entered in the right-hand column reserved for that purpose. All of these checks must be accounted for before the workman can obtain his final pay when leaving the employment of the company.

When a workman is assigned to a new job the first thing he must do is to make application to his foreman for the tools that he will require. If the foreman finds that the man is calling for the proper tools, he makes out an order on a form shown in Fig. 25, specifying the tools which are to be given to the workman by the attendant in the tool supply room in exchange for the proper number of tool checks. These checks are hung on the check board in the usual way. After the workman has finished with the tools, he will desire to return them to the tool supply room and get his checks back, but as the attendant in this room is not a skilled mechanic, the workman is required to first take the tools to his foreman, and have him see that they have not been damaged before they are returned. After the foreman has examined the tools and found their condition satisfactory, he fills in a form shown in Fig. 26, stating that the tools are in good condition and that the attendant in the tool supply room is authorized to return the workman's tool checks in exchange for the tools which he is returning.

Part No. 32460 — Check No. M4640
Operation No. #2 — Machine No. 2404
T. S. R. No. 22

Please give to bearer the following Special Tools:

Tool No.	Amount	Tool Description
53040	2	Jig for tapping

Also the following Commercial Tools:

Amount	Size	Description of Tools
2	3/16 x 18	Plug Hand Taper
2	3/16 x 18	Rod End Adj. Nut

These tools to be covered by one check and all to be accounted for before check is released.
Date 6-24-16 Foreman E. Moorhouse Dept. M 46
Use this form only when the number of tools on one job exceeds eight or when one man has more than one job.
T. S. R. Man J. A. Stroyan
DEPARTMENT FOREMAN'S COPY

Fig. 33. Form used by Shop Foremen in authorizing Tool Supply Room to deliver Sets of Tools to Men; Size 5¼ by 8 Inches; Two Copies on White and Buff Stock

Repair of Special Tools

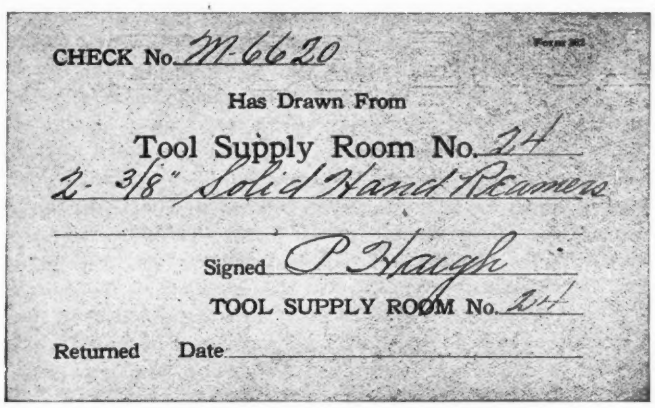
When the special tools used in any of the shops have become worn or damaged in such a way that they are no longer capable of giving satisfactory service, they are returned to the tool-room for the purpose of making the necessary repairs. The decision as to whether or not the tools require repairing will be made by the foreman of the department in which they are used. When a tool is sent from the tool supply room to the tool-room to have such repairs made, it will be evident that an order must be issued for doing the work, and also that the tool supply room must have a record showing what tools have been sent out for repairs. Fig. 27 shows the form of order made out. In the upper half of this card it will be evident that spaces are provided for not only recording the date on which the work was sent out and the date when the tool will again be needed in the factory, but also for specify-

SYMBOL 3504 — DATE June 28 1916 — ORDER NO. 2952 — FORM NO. 1225
TRANSFER SUB-DIVISION 43-A 10-28
SENT TO T. S. R. NO. 28 — FOR DEPT. NO. 820

AMT.	TOOL NO.	NAME OF TOOL	CLOCK NO.
1	49860	Jig for drilling 3/8" hole	8-2016
1	53020	" " Reaming 3/8"	

TRANSFER CLERK R. M. Bacon
T. S. R.—COPY — PER

Fig. 34. Form used by Maintenance Supplies and Tool Service Department in authorizing Temporary Transfer of Tools; Size 8¼ by 5¼ Inches; Four Copies on White, Yellow, Blue and Pink Stock


CHECK No. M-6620

Has Drawn From

Tool Supply Room No. 24

2- 3/8" Solid Hand Reamers

Signed P Haugh

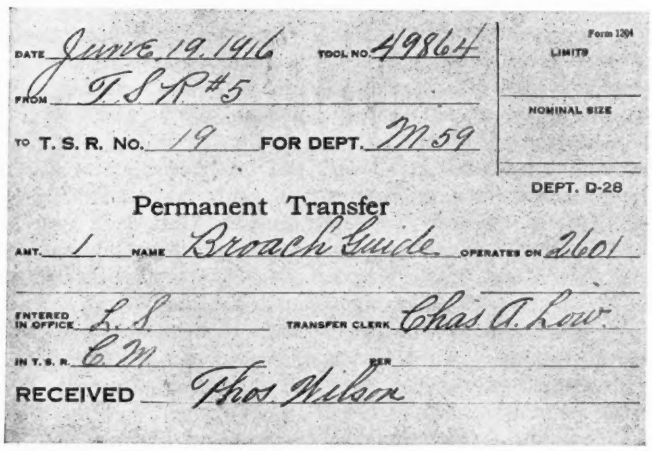
TOOL SUPPLY ROOM No. 24

Returned Date

Fig. 35. Form used by Tool Supply Rooms in reporting Withdrawal of Tools by Men employed in Departments not regularly served; Size 5 by 3 Inches; One Copy on Yellow Stock

ing the exact time of day in each case. This is an important matter, because it may frequently happen that damage done to a tool of which there is no reserve in stock will result in holding back production until repairs have been made. In repairing special tools, all work is done on a "blanket" order, No. 4923, and the insertion of this number in the space provided for the purpose shows immediately that the job consists of repairing a special tool. In the lower half of this form it will be noticed that spaces are provided for entering the name and number of the tool, together with the number of the part on which it operates. Under the heading "Remarks," the necessary instructions are given to indicate the nature of the repair that must be made.

It has been pointed out that when tools have been sent out for repair it is necessary for the attendant in the tool supply room to keep a record of the matter in order that he may not be called upon to deliver tools which are not in his possession. For the purpose of keeping this record, use is made of a form shown in Fig. 28, this form being made out in


DATE June 19. 1916 TOOL NO. 49864 Form 1204

FROM T S R #5 LIMITS

NOMINAL SIZE

TO T. S. R. No. 19 FOR DEPT. M 59

DEPT. D-28

Permanent Transfer

AMT. 1 NAME Broach Guide OPERATES ON 2601

ENTERED IN OFFICE L. S. TRANSFER CLERK Chas A. Low

IN T. S. R. C M PER

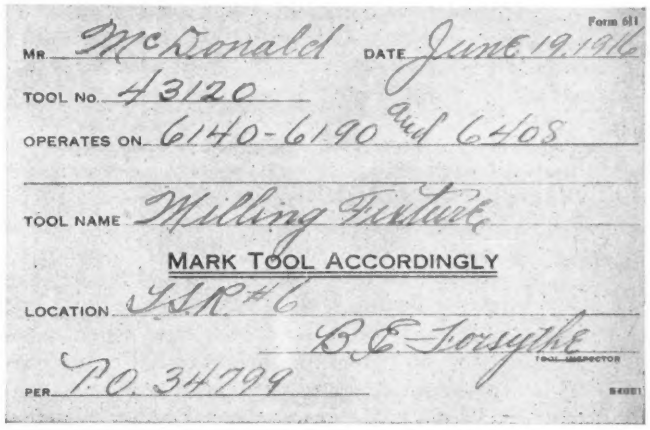
RECEIVED Thos Wilson

Fig. 36. Form used by Maintenance Supplies and Tool Service Department in authorizing Permanent Transfer of Tools; Size 6 by 4 Inches; One Copy on Buff Stock

triplicate. The first two copies are sent with the tool to the maintenance supplies and tool service department; and the first copy goes on with the tool to the foreman of the tool-room in which the repair is to be made, while the second copy is filed in the office of the maintenance supplies and tool service department. The third copy of the form is kept on file in the tool supply room, where it serves as a record of the fact that the tool has been sent out for repairs. When the tool is returned to the tool supply room, the card on file is signed and sent to the maintenance supplies and tool service department, where it replaces the second copy of the form, being placed in a permanent file to record the repair work.

Making Repair Parts for Special Tools

When a tool is in constant use in the factory, a serious delay is caused by sending it out for repair, and such a procedure is avoided just as far as possible. One way in which trouble from this source is largely overcome consists of having repair parts for the tool made in advance, so that it is only necessary to send the tool up to the tool-room for a long enough period of time to have the new parts put in place. For instance, suppose it is found that the bushings in a drill jig have become slightly worn and ought to be replaced. The most obvious method would be to send the jig up to the tool-room where the bushings would be made and put into place; but this would involve having the jig out of the shop for a considerable length of time, and production would be seriously delayed by following such a course. The method actually employed consists of sending an order to the tool-room, giving the number of the tool and the number of the blueprint of the tool drawing, together with a statement of what parts need to be replaced. The tool-room then proceeds to make these parts, and when they are finished and ready to put into place it sends for the tool. In this way the tool is only out of the shop for a short length of time and the delay occasioned is not serious. Fig. 29 shows the form used in ordering tool repair


Form 611

MR. McDonald DATE June 19 1916

TOOL No. 43120

OPERATES ON 6140-6190 and 6405

TOOL NAME Milling Fixture

MARK TOOL ACCORDINGLY

LOCATION T S R #6

B E Forsythe TOOL INSPECTOR

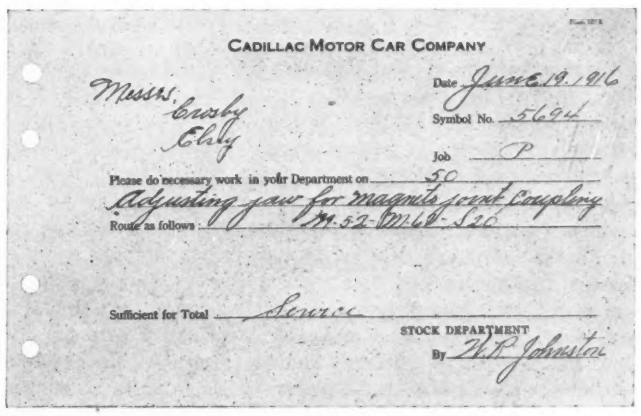
PER P.O. 34799

Fig. 37. Form used by Maintenance Supplies and Tool Service Department in ordering Supplementary Marking of Tools; Size 5 by 3 Inches; One Copy on Pink Stock

parts of this nature, this form being made out in quadruplicate. The first and second copies are sent to the foreman of the tool-room and serve as his order for making the parts in question. The third copy is filed in the maintenance supplies and tool service office until the job has been done, and the fourth copy is sent to the foreman of the department who placed the order for parts, to notify him that his order is being executed. These orders are all numbered, and all time and material is charged against that order number in the same manner as described in connection with the new tool orders.

Semi-monthly Report on Special Tool Repairs

In describing the work of repairing special tools, it will be recalled that stress was laid upon the importance of the time taken in doing the work. As a serious delay in the factory is likely to result where the time taken for repairing special tools is unduly long, it is important to check up the time actually required for tool repairing to see that there is no unnecessary loss of time. Semi-monthly inspections of the work


CADILLAC MOTOR CAR COMPANY

Messrs. Crosby Eddy

Date June 19. 1916

Symbol No. 5694

Job P

Please do necessary work in your Department on 50

Adjusting jaw for magneto joint Coupling

Route as follows M-52-M16-S26

Sufficient for Total Service

STOCK DEPARTMENT

By W. P. Johnston

Fig. 38. Form used by Stock Department in ordering Manufacture of Replacement Parts for Service Departments; Size 8 by 5 Inches; One Copy on White Stock

of the tool repair department are conducted for this purpose, and the conditions found are reported on the form shown in Fig. 30.

Discard of Worn Out Tools

As long as tools are in good working order they are charged against the maintenance supplies and tool service department; but as soon as they are broken or worn out this department is credited with the amount formerly charged against it, and a corresponding charge is made to the department in which the tools were used. When the usefulness of a tool is destroyed from either of these causes, it becomes necessary to make an adjustment of accounts, and data to form the basis of this adjustment are supplied on a form shown in Fig. 31. Referring to this illustration, it will be seen that at the left-hand side of the form, spaces are provided for the number of the department to which the value of the tool is to be charged, and also for the numbers of the accounts which are to be credited and charged with the cost of the tool. The space at the right-hand side of the form is filled in with a complete description of the tool, a statement as to whether it was worn out or broken, and with information which is used at the time an inventory is taken.

Sets of Tools for Special Operations

There are certain classes of operations which require the use of a considerable number of tools, and if a workman were required to have each tool out on a separate check, it would involve the necessity of supplying each of the men with an unnecessarily large number of checks. To avoid trouble arising from this cause, and also to simplify the method of handling tools, the expedient has been adopted of keeping such sets of tools in separate numbered boxes. This makes it possible for the entire set of tools to be delivered to a workman against a single tool check, thus greatly simplifying the work of the tool supply room. For the purpose of recording sets of tools of this kind, use is made of cards of the form shown in Fig. 32. One side of each of these cards carries a list of all special tools required for the operation, and on the other side of the card there is a list of all the standard commercial tools that are needed. It will be noticed that at the top notations are made of the number of the part for the manufacture of which the tools are required, and the box number in which the set of tools is contained. The cards are filed numerically by part number.

Drawing Out Sets of Tools

The practice of allowing a workman to draw out a complete set of tools on one check is only followed in cases where the number of tools required for a single operation exceeds eight, and where the workman is looking after more than one operation. When a man is assigned to a job of this kind, he must get an order from his foreman for the tools that he will require in doing the work, and such a tool order is made out on the form shown in Fig. 33. This order is made in duplicate, the first copy being held by the foreman and the second copy sent to the tool supply room, where it is filed in the same envelope with the workman's tool check and the copy of the transfer order shown in Fig. 34.

Drawing Tools from Tool Supply Room of Another Department

In the factory of the Cadillac Motor Car Co. there are thirty tool supply rooms, and each of these rooms is supposed to deliver tools and supplies to specific departments, the idea being clearly shown in diagrammatical form in Fig. 1. Charts are made out and blueprints of them posted throughout the factory, showing those departments to which each tool supply room is supposed to deliver materials and tools. But the rule in this connection is flexible, as it may happen that some department in the factory has urgent need for tools or supplies which are not in its proper tool supply room at the time they are required. When such a condition arises, a foreman may send his man to an adjacent supply room with an order for the tools which he needs. Delivery will be made on such an order, but the attendant in the tool supply room from which the tools are withdrawn will fill out one of the forms shown in Fig. 35 and deliver it to the tool supply room which should properly have handled the transaction, advising of the delivery of the tools to one of the departments served by this tool supply room. The purpose of sending this form is two-fold: in the first place, it serves to remind the attendant in the tool supply room that his stock of a given tool is out and must be replenished; and in the second place, it advises that men from departments which properly come under his jurisdiction have been drawing tools from another tool supply room. Should it happen that there was no necessity for withdrawing tools in this way, the attendant in the tool supply room will immediately take the matter up with the department foreman, so that the continuance of this irregular practice may be stopped.

Permanent Transfer of Tools

Occasionally a readjustment of the work in the factory calls for the permanent transfer of special tools from one tool supply room to another, and where this procedure is necessary, a record of the transaction is made on a card of the form shown in Fig. 36. Reference to this illustration will show that the card bears the date and tool number, together with the number of the tool supply room from which the tool was taken, and also the number of the room to which it was delivered. At the bottom, spaces are provided for a complete description of the tool. This transfer, when signed, constitutes authority for removing the tools from one tool supply room to the other, and also for changing the location on the tool card in the maintenance supplies and tool service office, after which it is filed by tool number.

Marking Additional Part Numbers on Special Tools

All the special tools used in the shops of the Cadillac Motor Car Co. are marked with a tool number, and also with the part number of the piece upon which they operate. So far, the matter is quite simple; but when motor cars of a new model are brought out, there will be a considerable number of special tools which can be used without alteration of any kind. But in order to bring the records up to date, it is necessary not only to add the part number of the new piece upon which the tool operates, but also to correct all records to show this addition. When the engineering department has decided upon a change of model and the work of providing the necessary tool equipment has been finished by the tool engineer, reports are sent to the maintenance supplies and tool service department; and a form shown in Fig. 37 is made out and given to the record clerk who adds the part number to all record cards, and then gives the notice to the toolmaker who sees that the tools are properly marked. Only such tools as are required for use on the model being manufactured are kept in the tool supply rooms. A tool storage is maintained in which are kept all obsolete tools. The bins in the storage room are numbered, and the location of each tool is carried on the tool record card filed in the maintenance supplies and tool service office. When it becomes necessary to use obsolete tools for making service repair parts, they are transferred temporarily to the tool supply room and returned to the storage room when the work has been done. The reason for this is that it would be undesirable to obstruct the tool supply room with tools that are only used occasionally.

Manufacturing Obsolete Parts for Purposes of Replacement

As all owners of motor cars know, and as anyone will readily understand by giving the matter brief consideration, it is necessary for automobile builders to maintain service departments in order to supply repair parts for obsolete models of motor cars which are still in use. A supply of such parts is kept on hand in the various service stations; and when the supply of any part is found to be running low, an order is sent in for additional parts of the same type. For manufacturing each part of the current model of a motor car, it is usually necessary to provide a number of tools of the same type; but when the car for which parts are used becomes obsolete, one of the special tools of each type will be set aside for the purpose of manufacturing replacement parts, while the remainder of the tools will either be changed to adapt them for use in the manufacture of parts of the current model, or else they will be discarded. A decision in this regard is made

by the tool engineer, whose experience enables him to decide whether it would be cheaper to modify the design of tools or to make new ones.

When one of the service departments sends in an order for replacement parts, the stock department issues an order for these parts, making use of the form shown in Fig. 38. This form is then sent to the maintenance supplies and tool service department, which refers to its card file of tools—the form shown in Fig. 19—which gives a complete list of the tools used in the manufacture of this part. The location of these tools in the storage rooms is then looked up, and all of this information is noted on the back of the form. An inquiry is then made of the foreman of the department in which the parts are to be made in regard to when he will be ready to do the work, and on that day the tools are delivered to his tool supply room on a temporary transfer form shown in Fig. 34. This form is made out in quadruplicate, and the trucker takes three copies with him when he goes to get the tools and transfer them from the storage room to the tool supply room, where the first copy is signed as a receipt for the tools and returned to the maintenance supplies and tool service department to be filed with the second copy of the form that was held as a memorandum of the transfer. The third copy is sent to the foreman of the department in which the tools are to be used, serving as a memorandum to advise him that the tools have been transferred to the tool supply room. The fourth copy is left in the tool supply room, and when the tools are checked out to the workman, this copy, together with the tool check, is put in an envelope bearing the symbol number of the part for the manufacture of which the tools are required. This envelope is kept in the tool supply room until the box of tools is returned, when the check is given back to the workman and the fourth copy destroyed.

Conclusion

The reader who is familiar with the performance of manufacturing operations on a scale such as that which exists in the factory of the Cadillac Motor Car Co. will be impressed by the fact that although means are provided for accurately recording all transactions involved in the ordering, making, distributing and accounting of special tools, the system has been worked out in such a way that there is no unnecessary complication. To the casual reader, it may appear that the use of so many forms must inevitably lead to confusion; but the filling in and transmission of many of these forms are merely incidental to the making and distributing of tools, and only a very small clerical force is required to look after all routine work of the maintenance supplies and tool service department. The benefits resulting from this system have made it quite evident to the management of the Cadillac Motor Car Co. that the expense involved in its installation and maintenance has been offset many times by the saving in lost and damaged tools, and the elimination of unnecessary delays in the process of manufacture which has resulted through having the entire tool problem placed under the jurisdiction of a central office.

* * *

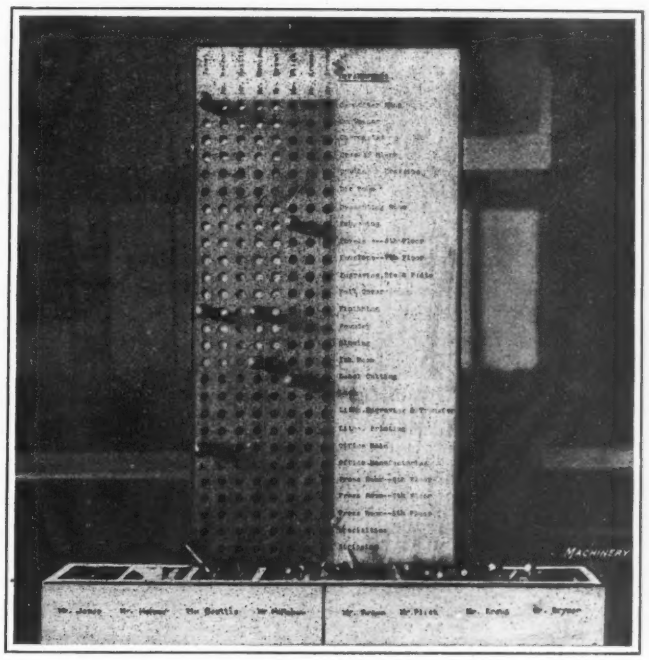
ADVANTAGE OF BALL BEARINGS FOR ELECTRIC MOTORS

A new booklet issued by the S. K. F. Ball Bearing Co. of Hartford, Conn., points out the advantage of ball bearings for electric motor armatures. The bearing adjustment remaining constant, keeps the rotor in the center of the magnetic field. This permits the motor manufacturer to employ air gaps with clearances so slight that they could not be considered on motors having the plain type of bearings. On induction motors a narrow air gap is of vital importance in the improvement of the machine efficiency and the motor power factor. Plain bearings after a period of service wear down, the amount varying with the load and service conditions. This wear, if long continued, finally permits the armature to touch the pole pieces, resulting perhaps in a stripped armature. But with ball bearings the armature is supported centrally and with practically no variation of position during the life of the motor. Thus the use of ball bearings improves motor efficiency and reduces the mechanical friction losses.

LOCATING BOARD FOR PLANT OFFICIALS

The accompanying illustration shows a clever and simple device for locating men in a large plant, whose work calls them into a number of different departments for a certain portion of the day. At first thought, to one who is familiar with the modern electric call system, this device may appear rather crude. However, it is being used very effectively in the large and splendidly equipped paper goods factory of Robert Gair Co., Brooklyn, N. Y. In this instance, the board is placed just outside the office of J. E. Jones, mechanical engineer, and directly in the path of his seven assistants whose names are given on the board. As the function of the mechanical engineer and his assistants is to keep the entire mechanical equipment of this large factory in repair, as well as to design and install new equipment, it is necessary for them to spend a great deal of their time outside the office. When they are out, it is essential to be able to locate them on a moment's notice, and it was for this reason that the locating board was devised.

The principle of this board is extremely simple, requiring but brief description. At the bottom is a tray containing eight compartments, each of which corresponds to the eight men in the department. In each compartment is a supply of plugs



Board for locating Men in a Factory, showing Three Men "plugged out"

of different colors to represent the different men. Starting with Mr. Jones' compartment and reading to the right, the colors of the plugs are as follows: red, white, black, green, brown, yellow, mahogany, and a combination of yellow and black. The holes are arranged in rows with a man's name at the top of each vertical row, and a department name at the right of each horizontal row.

By inspecting the illustration, it will be seen that Mr. Jones is going first to the carpenter shop, then to the finishing department, and then to the main office. Mr. MacMahon is going to the finishing department and then to the ink room. Mr. Flick is going from the embossing room to the label cutting department. As the man goes out the door, he slips plugs into the respective departments that he intends to visit. As he returns to the office he pulls out the plugs and returns them to the compartment bearing his name.

The device might be made somewhat more effective by having a flat top on the head of several of the plugs with successive numbers stamped thereon. By this method a man could indicate the sequence of his visits by placing the numbered plugs in the relative order in which he expects to make his visits. It might also be a good provision to include a row of holes horizontally labeled "Absent." In this case when a man expected to be away from his work for an entire day,

he could place a plug in the "Absent" column the night before, or whenever he was about to leave the factory, he might do likewise.

Several applications of the principle involved in this board may suggest themselves to the reader. A board of this nature ought to lend itself readily to the repair department of a large shop. As a man starts out for a certain department to spend anywhere from an hour to a whole day on a certain repair job, he might plug himself out on the board and make it a simple matter for the foreman to locate him at any time during the day. Thus the inefficient method of walking around the factory trying to locate a man and the loss of time involved can be done away with. V. B.

* * *

PRESS-ROOM LUBRICANTS

BY G. R. SMITH*

One of the chief factors of power press work is the use of the right lubricant for the right work. I have found a condition existing in many manufacturing plants that arises either through a false idea of economy or lack of study of existing conditions with a view to bettering them. While to the manufacturer with a small "now and then" class of production it might seem like needless expenditure, and no doubt would be in his case, to those who have a steady run on a certain class of work it is a point not to be lost track of. The lubrication of power press tools working on all kinds of operations and all kinds of materials should be made a careful study, as the life of the tools and machine, as well as the quality of work produced, is more dependent on this factor than almost any other entering into this mode of manufacturing. From long years of experience and careful study of certain conditions, I will endeavor to state a few rules and recipes that have given marked success and may be of great help to some others in a like field.

The practice of placing a barrel of machine oil in the press room and using it for all purposes, such as for oiling machines, as a drawing lubricant, as cutting and forming oil, etc., is one of the great steps in false economy. The composition of machine oil makes it especially adaptable for use on machines as a lubricant in journals, between collars, on ways, in shaft boxes, etc., but its composition also renders it very poor for cutting and drawing. Machine oil placed on small quick-action piercing punches and dies permits heating the steel and drawing the temper of the punch, causing the metal to flake off the stock and cling to the punch or drawing die. This produces rough, scratched work, and is generally bad when used in this way. A foreman has trouble with the tools, and wonders why the punches will not stand up, why they heat so easily and draw the temper, why the work is so rough, burred and scratched, especially on drawn shell work—when it is directly traceable to the use of machine oil in a service it was never designed to fill.

One of the best lubricants for cutting and punching, and in many cases for drawing also, is a good grade of lard oil. This perhaps is a little more expensive than machine oil, but it is obvious that machine oil can never take its place in this field. Lard oil cools the punches and places them in a better condition to perform their function; and it is really an admirable press-room lubricant on all kinds of work, while on the other hand it is very poor for oiling purposes around machinery. As a drawing solution for light brass and copper shells it has no equal, and in many cases works as well on light steel shells. I have also used it with marked success in broaching and lapping operations.

For heavy drawing work there are a number of lubricants on the market, all of more or less value on certain classes of work. One of the cheapest as well as most effective drawing solutions is a soap, oil and water emulsion. This is composed of equal parts of hard soap, lard oil and warm water, the hard soap being dissolved in the warm water first and the lard oil stirred in after. This is one of the best drawing solutions available for light brass and copper shell work, its only disadvantage being on work that has to stand any length of time between operations, the alkali in the soap having a tendency to corrode the brass; but on work where each operation is carried along to completion, this mixture will be found very satisfactory.

For heavy steel shell work I have used a mixture of dry white lead and lard oil of about the thickness of heavy paint with remarkable success. The drawing solution that I would prescribe for heavy and light steel shell work alike is a mixture of lard oil and precipitated chalk. After a thorough mixing, this should stand over night to allow it to "jelly" or grow softer, as it were; in fact, the longer it stands the better it gets, and for use it can be mixed to the right thickness to secure the desired results. The principle involved in shell drawing is to furnish a lubricant heavy enough and of the right nature to produce a film that will enter between the sides of the shell and the dies, thus lessening wear on the die and flaking of the metal resulting in scratches on the sides of the shell. These scratches are a grave defect on shells that are redrawn two or more times, as they cause the shell to split or crack open on the redraw. When shells are annealed between operations, and the best results are desired, an acid pickle should be prepared to remove the scale. This is generally of the same composition as the "bright dip" or the "firing off" that is used in the plating room. The lubricant that is used should be kept clean and free from dirt, scale and sediment, even if straining is resorted to, as drawing solutions must be clean to do the best work. In very heavy boiler-plate punching, blanking and cutting I have used cylinder oil with success. This is a very heavy oil, almost a grease, and gives very good results.

Non-metal materials require a varied assortment of lubricants to gain the maximum efficiency. In blanking and piercing mica parts, gasoline or kerosene is used, preferably gasoline. The mica dust collects and clogs the stripper parts and piercing punches, and gasoline used freely washes away this dust and adds to the life and effectiveness of the tools. In the blanking of celluloid and other camphor gum compositions of a like nature, I have used nothing but clean water. Some of these compositions do not stick to the tools at all, while others are very troublesome. If the water is not effective, a very little lard oil on the punch once in a while will be of value. Leather, cloth and felt I have always blanked dry, and on felt I work on one thickness only, with the punch entered deep in the die, as this material will cause the tools to shear unless great care is taken. On rawhide and horn-fiber parts, I have used wood alcohol successfully. Wood alcohol also softens the rawhide for forming and cupping, dries very quickly, and does the material no harm whatever. Fibers, as a general rule, can be cut dry, but in some cases lubrication, or rather washing out of the dies with gasoline, is required occasionally. Gasoline is very effective in this instance and does the fiber no harm. Glass blanks can be pierced successfully by laying them in turpentine and then piercing on a quick-action press. A press having a speed of 1000 revolutions per minute or more is required. The Campbell Mfg. Co. of Chicago, Ill., has brought out a clutch that will operate a power press having a greater speed than 3000 revolutions per minute.

Wood of certain kinds can be successfully pierced and embossed by first steaming or boiling, the work being done on a slow-action press with a long dwell, such as is used for cardboard forming. Foils, light tin, paper and cardboard, tapes and cambrics I have always cut and blanked dry. Cork can be successfully broached and turned by wetting first in good clean gasoline, the turning tool being emery, or stone of a like nature. In all classes of power press work, suitable lubrication and preparation of the material is the cardinal point.

* * *

A simple demonstration of the difference between the frictional resistance of a bearing with an unbroken oil film and one in which the film is broken can be made with a glass bottle fitted with a ground glass stopper. Oil the stopper and press it lightly into the bottle; it can be turned very easily, but if more pressure is applied the oil is squeezed out and the opposing surfaces come into intimate contact, with the result that the stopper can be turned only by the exertion of considerable force.

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LETTERS ON PRACTICAL SUBJECTS

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PRECISION GEAR CENTER GAGE

The accurate measuring of gear centers is not easily accomplished without the aid of special tools, but the simple form of gage illustrated and described herewith enables this work

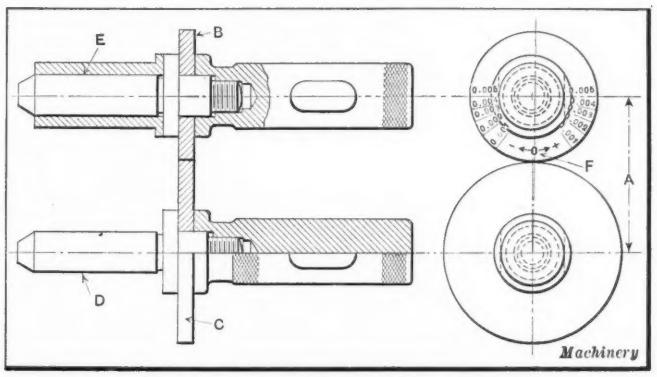


Fig. 1. Precision Gage for measuring Distance between Gear Centers

to be done quite rapidly. The method of procedure is as follows: Assume that center distance *A*, Fig. 1, is equal to one-half the sum of diameters of collars *B* and *C*. Arbor *D* of gage *C* fits into one hole, and the small diameter of gage *B* fits into the other hole at *E*. Referring now to Fig. 2, which shows angular spacing of different radii on gage *B* and the difference of these radii, we will assume that *F* represents the zero or datum point from which center distances are measured.

It will be evident that if we turn graduated collar *B* through an angle of 36 degrees, 51 minutes, in a clockwise direction, the center distance is + 0.001 inch; similarly, if the point of contact is located a similar distance on the other side of datum line *F*, we obtain — 0.001 inch. If the measurement of collar *B* is continued through an angle of 90 degrees, the center distance will be + 0.005 or — 0.005 inch, according to the direction in which the collar is moved; and for intermediate points the amount of eccentricity and whether it is plus or minus will be determined by the magnitude and direction of movement of the collar. The maximum eccentricity of 0.005 inch is far in excess of that actually found in practice, and to obtain a more accurate gage the maximum eccentricity may be reduced; for instance, making 0.003 inch the maximum, would mean that the graduations on dial *B* could be placed further apart so that the gage would read within 0.0005 inch of accurate.

The graduated collar should be made a standard for other center distances by simply increasing or decreasing the diameter of the plain collar. For instance, suppose it is required to measure a center distance of 5 inches and you have a graduated collar 3 inches diameter; it would be necessary to use a plain collar 2 inches diameter. Similarly, if you desire to measure a center distance of 7 inches with this graduated collar, it would be necessary to use a plain collar 4 inches in diameter. By making a series of plain collars for use in connection with the more expensive graduated collars, a universal outfit could be obtained at moderate cost. It would appear that a firm specializing in the manufacture of small tools could get up a useful combination to meet the requirements of automobile factories and other firms that have a lot of work of this kind to do.

INSPECTOR

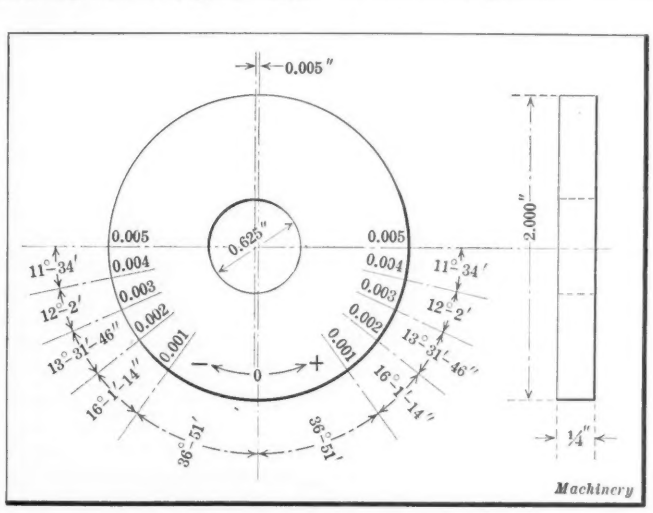
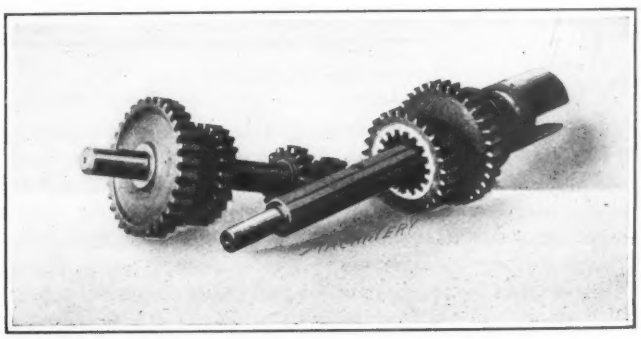


Fig. 2. Close View of Graduations on Collar B

UNUSUAL GEAR REPAIR JOB

At the Wentworth Institute, a few years ago, we were given the job of repairing the sliding gear transmission of a car that was no longer manufactured. The teeth of one of the gears shown in the accompanying illustration had been stripped off, making the gear of no further use, and in order to put it in condition we employed the following method with satisfactory results. An arbor was squared on the milling machine centers to just fit the hole in the sliding gear; and the damaged gear was then mounted on this arbor and the teeth ground off on a plain grinding machine so that the diameter of the gear was reduced to a point about ¼ inch below the bottom of the teeth. Then a ring made of 3½ per cent nickel steel had twenty-eight 6-pitch teeth cut in it instead of twenty-six teeth, which had been the number in the original gear, this increase in diameter plus ¼ inch previously mentioned giving a total thickness of 9/32 inch for the ring at the bottom of the teeth. This ring was then heat-treated and ground out to a diameter 0.0035 inch smaller than the gear on which it was to be pressed. In the accompanying illustration, the part of the original gear on which the ring was pressed is shown white; and a pressure of five tons was required to force it into place.

At the joint between the ring and the old gear, three holes were drilled to receive drill rod keys 3/16 inch in diameter, and particular care was taken to drill each keyway at the bottom of the center of a tooth in order to weaken the ring as little as possible. The steel was quite hard, but it was found possible to drill it with a drill having no rake, very slight clearance and run at slow speed, using a mixture of lard oil and turpentine as a lubricant. Even then, considerable patience was required to complete the job, but when the keys were driven into place a very satisfactory result was obtained. The mating gear was repaired in the same way, except that the number of teeth was decreased by 2 instead of increased as in the preceding case. After being in service for two years we took the gears out, cleaned them, and took the photograph that is reproduced here-



Satisfactory Method of repairing Obsolete Transmission Gears

with. The gears run nicely, and the faces of the teeth now have a good polish; so far as we can see, they are just as good as if they had been cut from solid blanks. Although this method of making the repair called for some careful work, it was much cheaper and quicker than making a new set of gears.

Boston, Mass. LEIGH J. RODGERS

TO DIVIDE A MIXED NUMBER BY 2

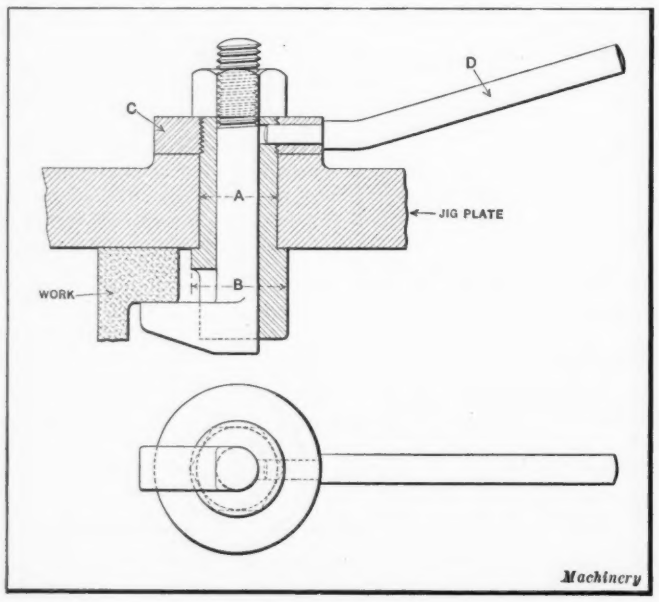
To divide a mixed number having an odd whole number by 2, subtract 1 from the odd number and divide by 2; then add the numerator and denominator of the fraction and use the sum for the numerator of the quotient, and multiply the denominator of the original fraction by 2 to obtain the denominator of the quotient. For example, divide 3 7/8 by 2; subtracting 1 from 3 and dividing by 2, gives 1; adding 7 and 8 equals 15; and multiplying 8 by 2 equals 16. The quotient is 1 15/16. Some readers of MACHINERY may appreciate this simple rule for dividing an odd mixed number by 2, as it can be done mentally by anyone at all proficient in figures.

Cleveland, Ohio. A. STEINICKE

IMPROVEMENT IN HOOK BOLT DESIGN

Many engineers will not consider the use of a hook bolt if a bolt can be employed with some form of head, and yet the tool designer must at times resort to this type of clamping device in order to obtain the results desired. A hook bolt of the ordinary type fails, owing to the fact that it has no support in opposition to the point where it is clamped, and hence as the pressure is applied, it becomes more or less bent with use and therefore does not clamp the work tightly; furthermore, it binds more or less in the hole. The bolt shown in the accompanying illustration is designed to overcome the defects mentioned. The diameter of the body *A* may or may not be as large as the nut over the corners, as the collar *C* takes the load. The nature of the work determines the diameter at *B* and the necessary clearance.

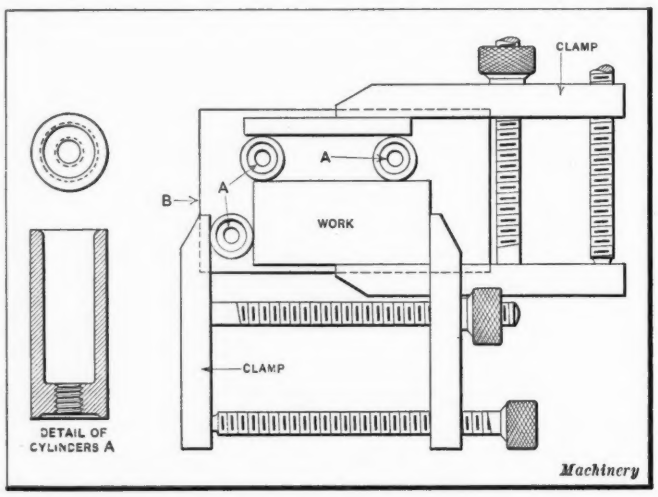
It is always well to so design the bolt that it will come as close to the work as possible, always, however, bearing in mind that if used on rough castings an allowance for variation should be made; whereas, if used for finished castings the bolt may come very close to the finished edge of the work. The handle shown at *D* is used for turning the hook and for locating it in a fixed relation to the work. A nut and washer are equally satisfactory without the handle. Applications of this design may be made to various classes of work, and it can be adapted to many conditions where it would be difficult to use other methods of clamping. INSPECTOR



Improved Type of Hook Bolt

SQUARING UP WORK ON A SURFACE GRINDER

Grinding small pieces square on the surface grinder is often a difficult matter, as it is seldom one can find an absolutely square block or angle plate against which to clamp the piece to be ground, and, of course, a small error on work of this kind multiplies rapidly as the piece is turned from side to side. In order to have something that could be relied upon, and also that would be light and easily carried in a tool kit, the following arrangement was devised, as here illustrated. This consists of the three cylindrical pieces *A*, shown in detail at the left of the illustration, made of tool steel and hardened, ground and lapped perfectly parallel, having the ends square with the sides. One end was bored out for the sake of lightness, while the other was tapped out to receive a screw for fastening it to the plate *B*. This plate can be of



Method of squaring up Work on Surface Grinder

any convenient size, and only requires to be ground parallel on its faces and the holes drilled and counterbored in it to receive the screw.

In use, the cylinders or buttons are first secured to the plate with screws, and then the work clamped against them as shown, in which position it is ready to be placed on the surface grinder and ground. The accuracy of the work depends upon the plate *B* being ground perfectly parallel, and also upon the accuracy with which the buttons are made. The latter, however, should not cause any great difficulty if care is taken in first grinding the cylinders parallel (this can be easily tested with a good micrometer), and then grinding the bottoms square with the sides at the same setting. To determine their truth, they should be tried out with a square after fastening to the plate, and if out of true a little, they may be carefully lapped on the ends until perfectly square.

Long Island City, N. Y. DONALD BAKER

"MADE-IN-AMERICA" DRAWING PENCILS

We often hear the remark, "The manufacturers of this country should go after some of the trade in Latin America and other countries formerly controlled by the different nations now at war." But how about the trade of the same manufacturing countries with us? Have we captured all the trade possible in articles commonly imported? I think not, and will cite one article indispensable to engineering provisions—the common, everyday drawing pencil.

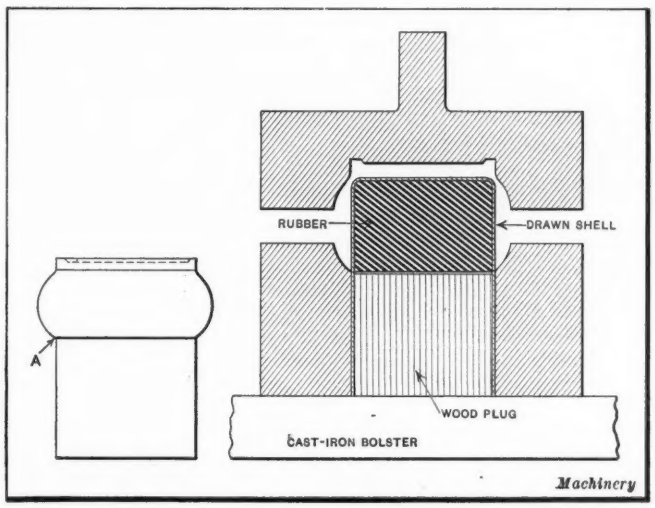
"Koh-I-Noor" is a pencil name familiar to engineers, architects and draftsmen from the day they enter the office or classroom; in fact, with many it has become a sort of fetish. They would not consider using any other make of pencil; they have always used that kind, so why change? This perhaps was all very well when this make of pencil could be readily obtained, but shortly after the beginning of the European war the supply of "Koh-I-Noor" pencils grew less and less, and the price advanced from 30 to 60 per cent.

For the past five months I have been using several kinds of domestic drawing pencils and have yet to notice any defects that would cause me to believe that the imported pencil is superior to the "Made-in-America" pencils. Perhaps some readers have found defects that I have not seen, but I do not doubt that if defects were found and the users had sufficient interest to make them known to the manufacturers, we would soon be able to obtain the very best grades in domestic drawing pencils. Users then would have the satisfaction of knowing that they are using a "Made-in-America" product.

South Orange, N. J. WILLIAM PHILIP

QUICK DIE JOB

Tools were nearly completed for the production of copper shells for percolator bodies similar to that shown at *A*; the shells had been blanked and drawn straight ready for the



Copper Shell for Percolator Body and Punch and Die for forming it

forming operation, which is usually accomplished by spinning. A special spinning chuck and roller are required for every variety of form spun, and in this instance, seemingly on account of the bulge in the form being deeper than ordinary, the spinning tools could not be made to perform the operation satisfactorily, but fractured the shells before the chuck and roller could be brought together close enough to start the form properly. Previous delays had made the delivery of samples of the goods over-due, and something had to be done quickly to help the job along.

The tool department foreman believed that the spinning tools would work satisfactorily if the form were previously started, and therefore had a punch, die and plug made from maple wood. At the first trial the shell did not expand, but collapsed and cracked open. To prevent this the mechanic on the job tried putting a piece of soft vulcanized rubber (cut from such a piece as is used under compound dies) into the shell before placing it on the wooden plug. The result of the next trial was even better than had been hoped for; the shells were formed so perfectly that spinning afterward was not really necessary. They were spun a little, however, to sharpen up the corner *A*.

To operate, it was necessary to withdraw the die (which was not fastened down) from under the punch, take out the finished shell, plug and rubber, reload with another straight shell and push the die back in place against two straps which acted as locating stops. Enough shells were formed for the samples required and cast-iron parts were ordered to replace the ones of wood. The time consumed from the starting of the wooden die until the first satisfactory shell was formed was three hours and thirty minutes.

Bayonne, N. J. WILLIAM A. HAWES

STRAIGHTENING HEAVY SHAFTS WITH COLD WATER

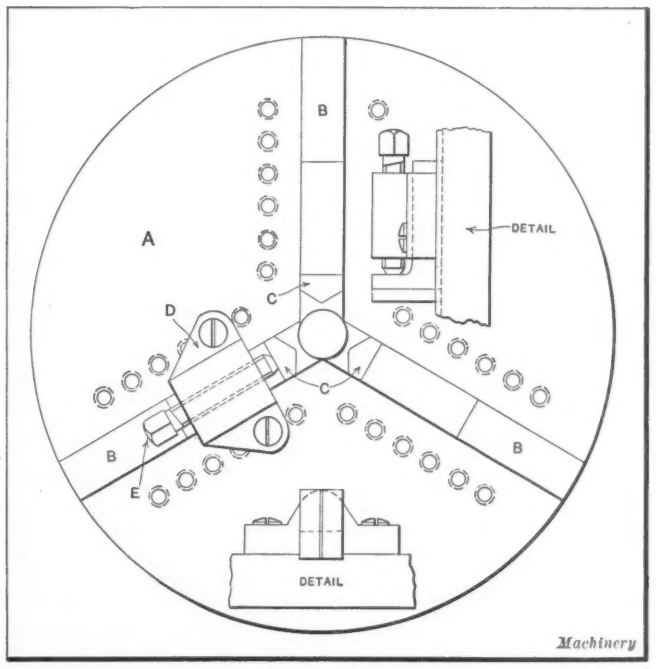
It is not generally known that it is possible to straighten heavy shafts with cold water. I had a connecting-rod 8 inches in diameter by 15 feet long on which a new end had been forged; and when I tried this rod on the lathe centers, it was found to be about ¾ inch out of true. I had it heated to a red heat and straightened it quite true; but after the shaft had cooled down to a black heat it "went back" sufficiently to show an error of ¼ inch. After experimenting for a little while I found that by pouring cold water on the "full" side of the bend while the hot shaft was rotating slowly, I was able to get a perfectly straight rod. The same method will be found useful in straightening heavy piping or for similar straightening jobs.

Toronto, Ont., Canada. THOMAS MASON

ACCURATE LATHE CHUCK

The jaws of the average lathe chuck seldom have a bearing for their full length on the piece of work which they are holding, and therefore cannot be depended upon to hold work perfectly square. They may work fairly well while new, if they have been perfectly fitted, but they soon wear, and the looseness between the jaws and the chuck body allows them to become bell-mouthed when tightened on a piece of work. The need of a chuck which could be easily kept true led to the design shown in the accompanying illustration, which shows a set of auxiliary jaws fitted to a bench lathe faceplate. *A* is the faceplate in which have been cut the shallow grooves *B* that the jaws *C* slide in. *D* is the strap which holds the jaws in place and carries the adjusting screw *E*. The strap is held to the faceplate by screws that enter tapped holes, as indicated, spaced to allow for shifting the strap to different positions as shown.

The illustration is clear enough to show the principle, but it is well to note that the chuck jaws and strap are hardened and ground on all wearing surfaces or points of contact, while the grooves in the faceplate are either scraped or ground on the surface grinder until they are perfectly parallel with the surface of the faceplate, as strap *D* must bind sufficiently on the jaws so that when the screws are drawn down tight the jaws will be a tight sliding fit. Special jaws for holding odd shaped or thin pieces can be easily made up, while any wear on the jaw faces can be remedied by regrinding on a surface



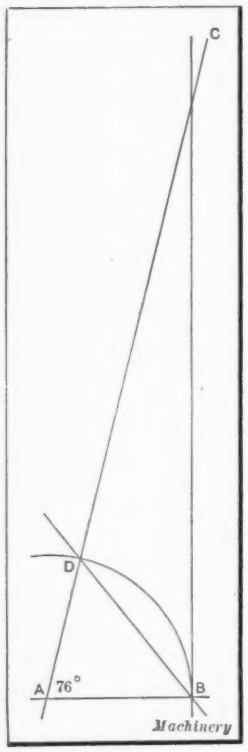
Accurate Lathe Chuck

grinder. While designed originally for use on a bench lathe faceplate for holding pieces that had to be turned, bored or ground accurately, there is no reason why the same principle cannot be applied to heavier work. It would prove cheaper and more accurate than the regular chucks on a large variety of work.

Long Island City, N. Y. DONALD BAKER

MEASURING ANGLES

In the July number of MACHINERY, F. B. Jacobs offers a method for measuring angles that he thinks is better than the one described by me in the May number. Mr. Jacobs overlooks several important points. The method I describe requires the use of a straightedge to produce one of the sides of the angle and a pair of dividers to describe an arc and space it. Mr. Jacobs' method requires a scale, two measurements, a geometrical construction, and a table of natural tangents. Moreover, for angles between, say, 75 and 105 degrees, it is practically impossible to obtain accurate results, since the point of intersection *C* cannot be located with any degree of exactness. (See illustration, which shows the construction for an angle of 76 degrees, the tangent of which is 4.01. Also see last sentence of the answer to the preceding question in the May number, which deals with the problem of dividing a right line into any number of equal parts.) Further, great care will have to be exercised to draw *BC* perpendicular to *AB*. If it is desired to use a table, the following method is to be preferred to that of Mr. Jacobs': with any convenient radius, say 5 inches, describe the arc *BD;* measure the chord *BD;* then, $\sin \frac{A}{2} = \frac{BD}{2AB} = \frac{BD}{10}$. Since an arc always intersects its radius at right angles, the points of intersection can be readily determined in all cases. For angles less than 45 degrees, Mr. Jacobs' method will give accurate results, though probably not as accurate as the method described by me. J. J.

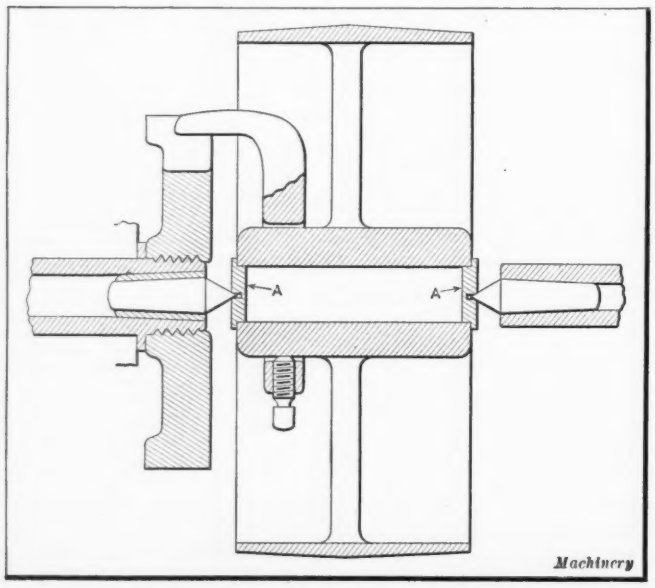


Measuring Angles

TURNING PULLEYS MOUNTED ON CENTER PLUGS

Pulleys and similar parts are usually turned on an arbor; but work of this kind can be handled on two center plugs which are a snug fit in the hole, as shown in the accompanying illustration; and very satisfactory results will be obtained in this way. The center plugs are provided with a small recess under the shoulder so that they may be pried out with a screwdriver.

Miami, Ariz. H. B. SAVAGE



Center Plugs used for turning Pulleys on Centers

COMBINED BLANKING, DRAWING, FORMING AND PIERCING DIE

The muffler cup shown in Fig. 1 is finished complete as shown in one operation by means of the combination blanking, drawing, forming and piercing die shown in Fig. 2, in a single-action press. The operation is as follows: When the blanking punch descends, it enters the blanking die, the blank being held firmly by the drawing ring against the bottom of the blanking punch in order to prevent wrinkles in the metal. The pins shown are used to transfer the pressure. As the downward movement continues, the blank is drawn between the bore of the blanking punch and the drawing punch. As it reaches the end of the stroke, the rim is formed between the recess in the blanking punch and the tapered shoulder on the drawing punch; holes are pierced by punches located in the punch-block, as clearly

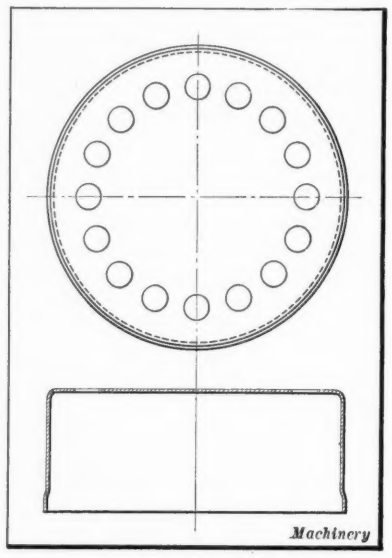


Fig. 1. Automobile Muffler Cup

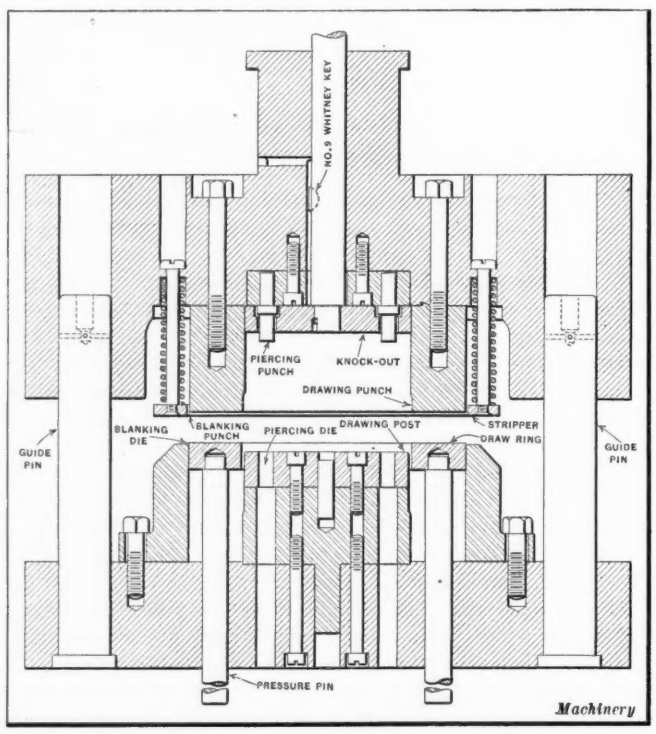


Fig. 2. Combined Blanking, Drawing, Forming and Piercing Die for Automobile Muffler Cups

indicated in the illustration. A spring stripper is used on this work and a knock-out is kept in line with the piercing punches by a Whitney key.

Norfolk Downs, Mass. W. L. JONES

GEARING FOR ROLL FEED

A roll feed is shown in the August number of MACHINERY on page 1053, which I think could be improved upon by eliminating the train of spur gears connecting the two sets of rolls. Instead of using the train of spur gears, I would have continued the horizontal shaft across to the second set of rolls, and connected them by another pair of bevel gears similar to the first pair.

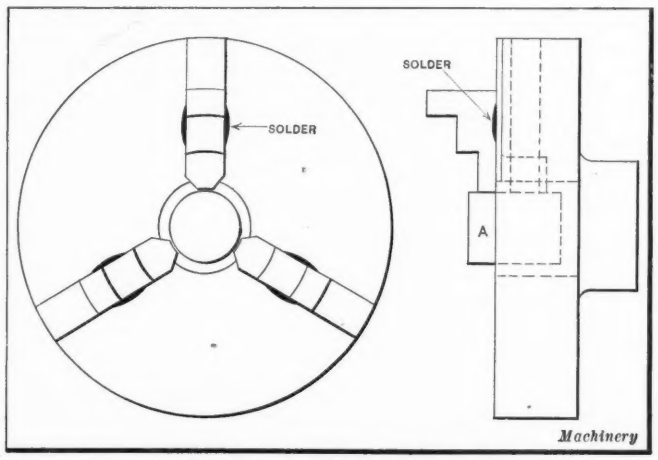
A better location for the horizontal shaft would be at the

back, provided the conditions would permit, and this would result in easier access to the dies. I. L. C.

An important principle in machine design is touched on by I. L. C. in the foregoing. In all cases, wherever possible, power for driving a series of rolls or other machine elements should be conveyed by shafts rather than by trains of spur gears. The reason is that with a train of spur gears frictional resistance is cumulative, and in long trains it may become so great that the mechanism as a whole is inoperative. Another objection to trains of spur gears in such situations is that lost motion is also cumulative and may become prohibitive if the train is long. With a longitudinal shaft, however, frictional resistances are proportional directly to the number of units driven, and lost motion is no more for ten than for one set of elements.—EDITOR.

GRINDING CHUCK JAWS

The article by R. Gordon Edjell in the August number of MACHINERY on truing up the jaws of scroll chucks reminded the writer of a very satisfactory method of grinding chuck jaws which is in use in the tool-room where he is employed. Having had considerable trouble in producing a good, true job by other means, it occurred to the writer that the desired result could be reached by gripping a cylindrical piece *A*, shown in the accompanying illustration, in the chuck with a fair pressure, lightly soldering each jaw to the face of the chuck, and then driving piece *A* carefully out of the jaws. This leaves all the steps open and free to be ground by a tool-post grinder on the carriage, the jaws being left in the position in which they grip the work, and produces accurate surfaces on the jaws. After grinding, the solder can be easily scraped from the surface of the chuck. If preferred, the jaws could be soldered to a small brass or steel angle instead of in the joint, which would facilitate removal of the solder.



Suggestion for grinding Chuck Jaws

Aurora, Ill. CORWIN LAMOREAUX

LAYING OUT DIAGONAL STRIP IN RECTANGLE

In the July number of MACHINERY, J. J. gives a solution to the problem of finding the length of the longest rectangle 3 inches wide that can be laid out in a rectangle 24 by 40 inches. This problem has been solved from time to time in various ways, but it is thought that the following trigonometrical solution will be found to be the shortest method. Using the notation given in the accompanying illustration, we have:

$AB = m \sin \phi$

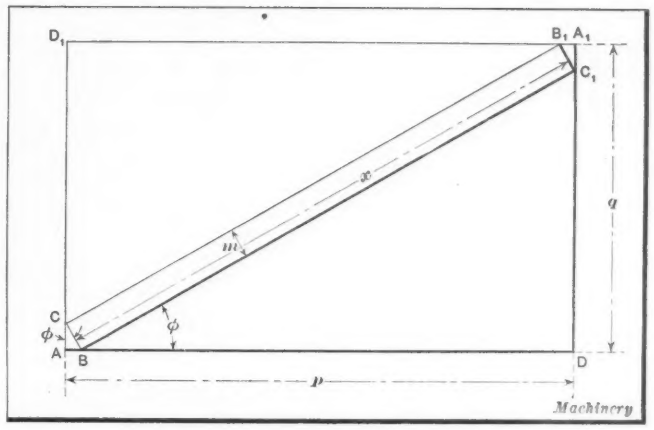
$BD = x \cos \phi$

and $AB + BD = p$

Then

$$m \sin \phi + x \cos \phi = p \quad (1)$$

$AC = m \cos \phi$, $CD_1 = DC_1 = x \sin \phi$, and $AC + CD_1 = q$.



Laying out Diagonal Strip in Rectangle

Then $$x \sin \phi + m \cos \phi = q \quad (2)$$

Solving Equations (1) and (2) for $\sin \phi$ and $\cos \phi$, we get:

$$\sin \phi = \frac{pm - qx}{m^2 - x^2} \text{ and } \cos \phi = \frac{qm - px}{m^2 - x^2}$$

Squaring, adding, and making $\sin^2 \phi + \cos^2 \phi = 1$, we get:

$$\left[\frac{pm - qx}{m^2 - x^2}\right]^2 + \left[\frac{qm - px}{m^2 - x^2}\right]^2 = 1$$

Expanding, clearing of fractions and reducing, we obtain:

$$x^4 - (p^2 + q^2 - 2m^2)\, x^2 + 4pmqx - (p^2 + q^2 - m^2)\, m^2 = 0$$

With $p = 40$, $q = 24$, and $m = 3$, we get:

$$x^4 - 2194x^2 + 11520x - 19503 = 0$$

Solving this equation by Horner's method, we find $x = 44.07637$ inches, the length of the diagonal strip.

Cleveland, Ohio. WILLIAM W. JOHNSON

GRINDING NARROW PARALLEL STRIPS

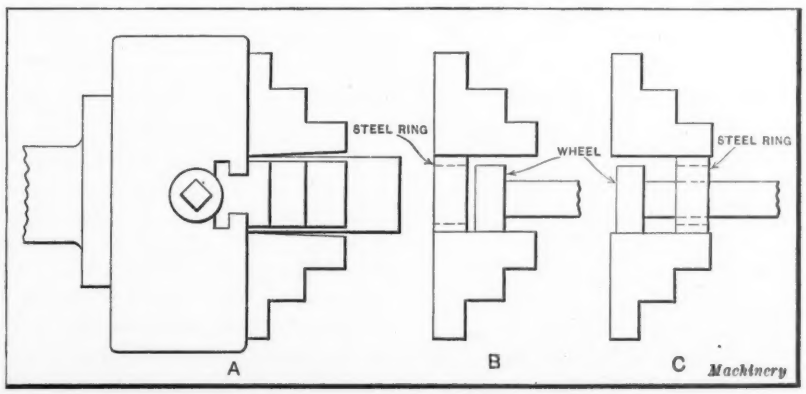
In the August number, "Server" writes in "Grinding Parallel Strips," "Why did not my foreman tell me if the present method represents common practice?" The reason the foreman did not tell "Server," in all probability, is simply that he did not know. I have found that most foremen and tool-makers know very little about surface grinding. They do not know what kind of wheel to use on their work; they generally use any wheel that is on the machine. The best wheel for a Brown & Sharpe surface grinder for general use is a Norton wheel, 46G, 7- by ½-inch face.

When grinding narrow parallel strips it is not necessary to solder them together as described in the August number. Put a parallel about ⅛ inch narrower than the strips in front of them on a magnetic chuck, and on each side if they will not stand up. Then you can grind as many as the chuck will hold.

When grinding jig bushings or punches, if it is necessary to grind on parallels, one of the parallels should be placed on the outer side of the chuck; this will hold a good deal better than when both are put in the center. A. GRINDER

TRUING JAWS OF SCROLL CHUCK

On page 1077 of the August number of MACHINERY, R. Gordon Edjell describes a method of truing the jaws of a scroll chuck, and I think a little further comment on the subject will be of interest to many readers. The retruing of scroll chucks is generally occasioned by the jaws becoming worn at the front; other portions of the chuck and jaws also become worn or strained, with the result that they grip a piece in the manner illustrated at *A*.



Suggested Improvement in Method of truing Chuck Jaws

One of the most im-

portant rules for an internal lapping job of this sort is to keep the lap moving in and out continually while lapping. The only manner in which this could be done, still preserving Mr. Edjell's principle, would be by means of the bar and bushing mentioned. The bushing should slide on the bar. It is a fact that unless a reciprocating motion is imparted to the lap, it will speedily become grooved; also, it will become worn more at those points where the most lapping is done. If the jaws of the chuck are as badly worn as some I have seen, grinding should be resorted to.

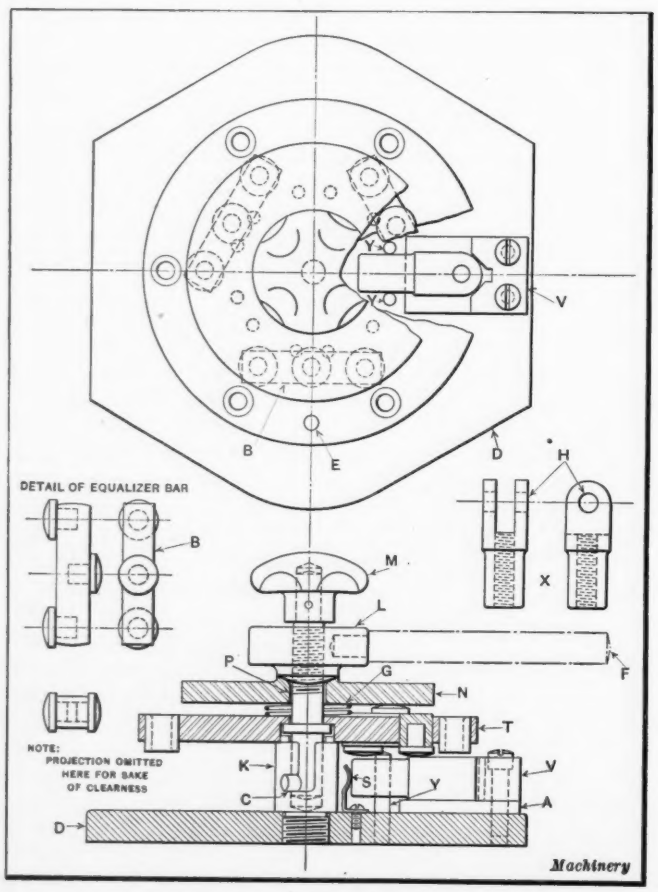
Mr. Edjell's objection to grinding is that the jaws will be slack during this process. This slackness may be removed as shown at *B* and *C*. A steel ring may first be placed as shown at *B*, while the exposed portion of the jaws is ground true. If the wheel is too large to admit passing through the hole in the ring, it may be removed from the spindle, the ring placed over the spindle, and the wheel, spindle, etc., moved into the chuck, the ring being gripped as shown at *C* and the untrued portion of the jaws finished.

Newark, N. J. GUSTAVE A. REMACLE

DRILL JIG FOR ADJUSTABLE YOKE END

In automobile nomenclature, the part shown at *X* in the illustration is known as an adjustable yoke end. Even the simplest motor car employs many such parts, and it will therefore be understood that jigs for drilling these yoke ends must be designed with a view to high production. The accompanying illustration shows a jig used for drilling the hole *H* in six yoke ends at the same time by means of a multiple-spindle drill head. Although complicated in detail, this jig functions very rapidly.

It is required that the hole *H* be practically concentric with the round end, so the piece is located in a V-block, between the two pins *Y*, shown in the upper view where the plate is broken away. The locating is accomplished by pushing the yoke end between the V-blocks *V* and the flat steel springs *S*. The bushing plate *T* and the entire clamping assembly is removed at this time to make the jig accessible. After the parts have been placed in position in the jig, the bushing plate and assembly are put back in place, and as the pin *C* enters the slot, it is pushed down to the bottom of the socket *K* and locked by turning the knob *M* clockwise. The bushing plate is brought to the right position by registering with the pin *E*, which location also brings the lower buttons of the equalizer bars *B* directly over the yoke ends. Turning the nut *L* clockwise by means of the removable handle *F* brings it against the spherical seat of the clamp plate *N* which, in turn, compresses the helical spring *G* and brings the equalizer bars against the work. The handle *F* is then removed and the work drilled. Reversing the process and rapping the base-plate *D* against the drill table releases the work. The function of the helical spring *G* is to keep the plate *N* against the nut *L* so that a small movement of the handle *F* will permit of unclamping the plate. A hardened steel plate *A* is provided for a seat on which the work rests. It should be noted that the slot in the yoke end is milled out in an operation following the drilling.

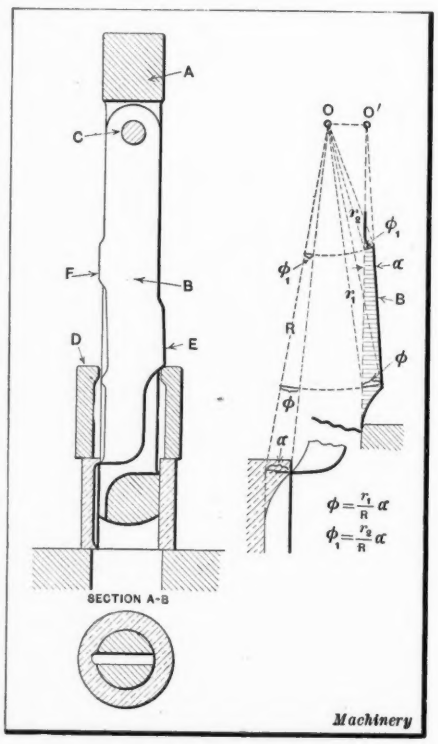


Drill Jig for Adjustable Yoke End

Bridgeport, Conn. W. BURR BENNETT

OIL-GROOVE CUTTING TOOL

If many bearings having the same inside diameter are to be grooved for oil with a straight groove as shown in the accompanying illustration, a tool must be designed especially for this purpose. This tool has a number of advantages over the type of tool which has a special feeding device for obtaining the correct depth of groove, the most important of these advantages being that no special machines or fixtures are necessary for the operation. The tool-holder *A* is slotted out to receive the grooving tool *B*. This tool is pivoted on the pin *C* so that it can move freely. The work is so located on the fixture base that the bushing *D* is directly above it. The bar from which the tool is made is formed at *E* and *F* so that as it strikes the edge of the bushing it is carried into the work and out again as the tool travels downward. A light arbor press of the hand type can be used for the operation with excellent results. The diagram shown at the right-hand portion of the illustration shows the method of plotting the cam surfaces *E* and *F* to produce the desired result on the inside of the bushing. Lines drawn from the center *O'* to the angle α intercept ordinates for the cam at any position of the tool.

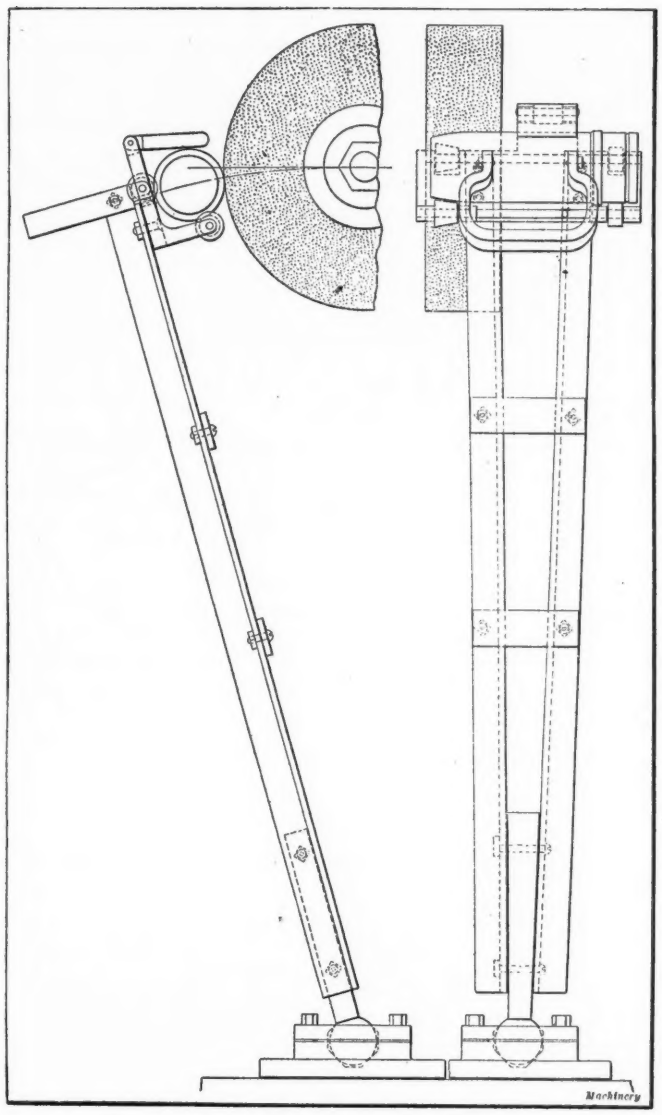


Oil-groove Cutting Tool

Avenel, N. J. ADALBERT O. ALEXAY

POLISHING FIXTURE FOR SHELL NOSES

In the manufacture of shrapnel shells there are two methods of finishing the nose of the shell after hardening. The specifications call for a polished nose, and one method is to grind these shells on centers, using a form wheel. The other consists in finishing this surface by polishing on a leather faced wheel that has been set up with fine emery. It will be appreciated that to hold the shell by hand steadily and turn it evenly while polishing is not an easy job. To facilitate this operation one of the large shell manufacturers has built the device shown in the accompanying illustration that takes



Support for Shells when polishing

care of this operation very well. Incidentally, this type of fixture can be employed to good advantage on cylindrical work of any diameter, whether shells or any other product.

The polishing head and wheel are no different from the usual type of polishing apparatus. The fixture consists of a pair of angle-iron strips that are mounted on a ball and socket base, attached to the floor under the machine. These angle-iron strips are strapped together, and just below the axis of the wheel is the shell holder. The shell holder or cradle consists simply of two sets of friction rolls on which the shell is laid. At the top is a hinged plate that is thrown over the shell and used as a brake. The operator grasps the handle and applies a slight pressure against the wheel. This causes the shell to turn slowly and polishes the surface, as the wheel surface travels much faster than the shell. For reaching the different parts of the curve, the entire fixture is rocked on its axis. The hinged brake above is for the purpose of retarding the rotation should a shell obtain too much momentum, and it is operated by hand pressure.

After polishing a few shells, the operator becomes dexterous in its manipulation, and production is far in excess of that obtained when working free-hand. C. L. L.

CLOCK TROUBLES

A watchmaker—a good one—bought a regulator of high grade and price, set it up with pride and joy, but found that the time it kept was hardly up to seventy-five-cent watch standard. Careful and prolonged study of its eccentricities revealed that its performance was in cycles. It did well for a certain length of time, and then for a shorter period it gained, again was righteous for a season, and so on. It seemed to the watchmaker, as a reasoning being, that this indicated trouble in the "great wheel" (the first in the train, which carries the drum for the cord), but careful inspection failed to find the "bug" either there or elsewhere in the movement. Finally, a friend was summoned who was supposed to be clockwise; he looked where no one, not even the inspector at the maker's factory, had looked before, and found that the pulley on top of the weight was out of square with its arbor, so that at one point in its revolution it rubbed against its housing. That was all.

Another watchmaker set out to build a clock that should be an exact replica of a fine astronomical one which he had been employed to clean, all the dimensions, etc., of which he had noted for this purpose. A toolmaker friend bored all the holes in the plates with the utmost attainable accuracy, roughed out the staffs from drill rod and hardened them. Mr. Watchmaker ground them all over, jeweled every pivot hole in the plates, put in sapphire pallet stones, and, in short, did everything he knew to get a perfect job. I never have seen a finer piece of work. Yet when it was set in motion it proved unreliable, keeping nearly perfect time for four or five days, then showing a different rate for the rest of the week. To be sure, the owner might wind the clock twice a week, and thus get good results, but you and I know how unsatisfactory this would be to a man who had made what he intended for a masterpiece. After worrying over the problem for some weeks, he put it up to his toolmaker friend, knowing he had had a good deal to do with fine clocks. The advice he received seemed to him absurd, but he tried it, and found to his great surprise that the trouble was entirely cured. This "senseless" advice was to insert a plate of glass between the path of the weight and the plane of motion of the pendulum. After being convinced of the successful working of this device, the reason was explained to him.

In copying his model he had made one slight change, reducing the depth of the movement in order to make it fit a fine case that he owned. This brought the weight, at the lower end of its course, quite near the swing of the pendulum bob, and the weight, interfering with the air currents set in motion by the bob, had affected the rate of the pendulum. When I was first taught this point, many years ago, I was skeptical till experiment showed me its correctness. Later, by changing the insertion of the cord into the drum, so that the weight, at its low point, was farther from the bob by the drum's length, he was able to dispense with the glass. As indicating the excellence of workmanship in this case, I may mention the fact that the weight, though made large for the sake of appearance, was a hollow affair, weighing only a trifle over one-half pound.

In still another instance a costly clock of foreign manufacture had one rate for the first two or three days of the week and another for the later days. Through faulty design the drum was so small that the cord, when fully wound, made one complete layer on the drum and part of a second. A new drum, with the necessary alteration in the weight to compensate for the increased leverage, removed the trouble. I think this fault is never found in an American clock. In justice to American makers, I wish to say that the instance mentioned in the June number of MACHINERY is the first case I've ever known of a 'scape or other train wheel being out of center in a Yankee clock. Even in Europe, where they are subjected to scathing criticism, it is universally admitted that, with all their faults, American movements are faultless in truth of wheels and correctness of "depthing" (the center distances between wheels).

I know of a fine imported mantel clock, a beautiful piece of mechanism, jeweled, with "Brocot visible" escapement, gold-plated 'scape wheel of hardened steel, ruby pallet stones, etc., which cost in its marble case, over $100 at retail. This clock ran well for nearly a year, was then cleaned and ran six months. It was found that its escape wheel was 0.006 inch out of center. The hole was ground true, a bushing inserted, and all was well. Of course, 0.006 inch isn't much, and the movement ran, in spite of it, till it got a bit dirty.

New London, N. H. GUY H. GARDNER

HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

RAKE OF SHEAR BLADES

D. E. T.—What is the inclination or rake of the upper blade in a power shear?

Answered by the Long & Allstatter Co., Hamilton, Ohio

A.—It is not feasible to make all shear blades with the same rake; but we generally give ¾ inch to the foot for cross-cutting bars, and as near this as possible for splitting plates. But the variation in thickness of material and the length of sheet to be cut requires the blade to be set at different rakes in order to adapt the machine to the desired capacity. Sometimes we do not give more than ½ inch rake to the blade, and if it is, say, ten feet long, this requires a stroke of five inches. If the sheet is very wide and we cannot get the amount of rake to the blade owing to the length of knives, we are obliged to use a larger and heavier machine, because there is more work to be done at one stroke of the slide.

CASTING BRASS NUTS ON FEED-SCREWS

T. M.—We are using a large number of brass nuts for the cross-feed screws of our cutting-off lathes on shell work. The screws are 1¾ inch outside diameter, 4 inches in length and 4 threads per inch, square thread. Two nuts are used in each machine on right- and left-hand threads. We are cutting the nuts in a lathe, but they do not give satisfactory service. I worked for a company in England where all the brass nuts were cast on their own screws, and they made a good hard-service nut. Can you furnish information on the subject and tell what kind of coating should be put on the screws before casting the nuts? Should the screws be heated before pouring the metal around them? The hard skin secured by casting the nut on the screws makes a good wearing nut, and I am desirous of getting information on the process.

The inquiry is referred for answer to any reader having had experience with this class of work.

THE MATTER OF PERCENTAGES

L. A. B.—I noticed a statement in the August number to the effect that the output had been increased over 400 per cent. I was taught that 100 per cent of anything was the whole and it was impossible to have any more. I have run across the same statement in newspapers, magazines, technical books, etc., which has made me wonder if the basis of percentage had been changed. Will you please enlighten me on the subject?

A.—It is quite correct to state that the output had been increased 400 per cent provided it was five times the original output. If the output were quadrupled, the percentage of increase would be 300 per cent; if it were tripled, 200 per cent, and if it were doubled, 100 per cent. The error in statement of percentages to which you refer doubtless applied when they were matters of decrease. For instance, if the cost of doing a job were cut in half, it would not be correct to say that it was decreased 200 per cent. Obviously the cost could be cut only 100 per cent, and then the cost would be nothing. If the cost is cut in half, the decrease is 50 per cent; if it is cut to one-third, the decrease is 66 2/3 per cent, etc.

KILOVOLT-AMPERE

S. B.—What is the meaning of the term "kilovolt-ampere" as used in connection with various electrical machines? The writer always has known of electrical machines as rated in kilowatts, but has recently seen a number of catalogues in which the rating is in kilovolt-amperes.

Answered by E. A. Lof

A.—The term kilovolt-amperes (KVA), equal to 1000 volt-amperes, expresses the *apparent* power in a circuit, *i. e.*, the product of the effective values of the current and the voltage, *IE*, in a reactive circuit. The term kilowatt (KW), equal to 1000 watts, on the other hand, expresses the *true* power, $IE \times \cos \phi$, and is the reading obtained by a wattmeter applied to the circuit. The ratio of the watts to the volt-amperes is called the *power factor*. For example, assume an alternating-current generator supplying a load of 800 kilowatts, the power factor of which is 80 per cent. The true rating of such a generator, or the one on which the capacity of the prime mover should be based, would be 800 kilowatts, while the apparent rating of the generator would be $\frac{800}{0.80} = 1000$ kilovolt-amperes. To avoid any misunderstanding, the rating usually appears as follows: 1000 KVA (800 KW, 0.8 power factor). For direct-current generators, however, the rating is always given in kilowatts, inasmuch as such machines always operate on non-inductive load.

The rating of a synchronous machine is usually determined by its permissible temperature rise caused by the current. This rise increases with increasing load and with decreasing power factor. Thus, for a given kilovolt-ampere output, the total heat losses are larger for low than for high power factors, the difference being due to the heat generated by the increased field current which is required to overcome the armature reaction and maintain the given current and terminal voltage.

PEAUCELLIER'S COMPOUND COMPASS

T. L. M.—In the August number of MACHINERY, Frederic R. Honey describes several linkages for producing straight lines; have these ever been used in practice? Where can I obtain more information regarding these and other linkages?

A.—Both the first and second forms of linkage described by Mr. Honey have been used on the walking beams of pumping engines or for similar purposes; and either form could be used on a steam-engine indicator, provided the weight of the moving parts were sufficiently reduced. One of the most interesting applications is found in the compound compass—a very useful instrument for any drafting-room, and one that the writer has used with good results. Referring to the accompanying illustration, link *oD* is equal in length to distance *oA*. A graduated scale, to which is attached a vernier for accurate setting, is placed between *A* and *D*, the edge of the scale coinciding with the line *AE*. The end *o* of link *oD* can be moved along this scale to the right or left of point *o*, which is the zero mark on the scale. At joint *E*, there is an arrangement for holding a pen or pencil point; and when the end *o* is at the zero mark, the pencil at *E* will describe the straight line *FG*. When *o* is at any point to the right of the zero mark, as *o'*, the pencil will describe an arc of a circle, as *HEI*, tangent to *FG* at *E*; and when *o* is to the left of the zero mark, as *o''*, the pencil will describe an arc of a circle, as *JEK*, which is also tangent to *FG* at *E*. By means

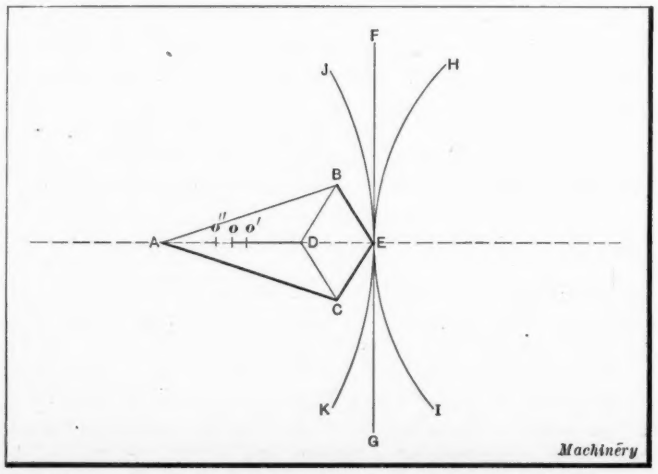


Diagram illustrating Principle of Peaucellier's Compound Compass

of a simple formula, the position of o' or o'' may be calculated, whereby the resulting arc may be of any radius desired. The instrument is chiefly employed when arcs of large radii are to be drawn and a beam compass is inconvenient to use. A full description of this and other linkages is given in Weisbach's "Machinery of Transmission" (Wiley); it is also fully treated, together with many of its modifications, in "Linkages," by J. D. C. De Roos, in No. 47 of Van Nostrand's Science Series. The latter work is of great interest to those mathematically inclined, as it shows how the linkage may be modified to find the roots of numbers and equations, and to describe conic sections and other curves. J. J.

FIFTH ROOTS OF NUMBERS

A. H. M.—In the August number of MACHINERY, you give a small table to be used in connection with finding the fifth root of numbers. Please show me how the values in the third column are found; I think this would be useful to know when finding other roots by the same method.

A.—Referring to page 1085 and using the same values for the letters, r = the root to be found; m = the given number; n = the index of the root; x = an approximate value of the root. Then $r = \left(\frac{m}{x^n} + n - 1\right)\frac{x}{n}$. If the values in the third column be called the limiting values for the first approximate value of x, and be represented by L, then $L = \frac{(n-1)\,x^{n-1}\,(x+1)^{n-1}}{(x+1)^{n-1} - x^{n-1}}$. For example, if $x = 2$ and $n = 5$, $n - 1 = 4$, and $x + 1 = 3$. Substituting in the formula for L, $L = \frac{4 \times 2^4 \times 3^4}{3^4 - 2^4} = 79.7$, the same value as in the table. For cube root, $n = 3$ and $n - 1 = 2$. For $x = 4$, say, $x + 1 = 5$, from which $L = \frac{2 \times 4^3 \times 5^3}{5^3 - 4^3} = 88.9$. The values of L for the cube root corresponding to $x = 1, 2, 3$ .....9, 10, are 2.67, 14.4, 41.1, 88.9, 164, 271, 418, 610, 853. It is not advisable to use more than three figures for L. J. J.

SIGN OF A BENDING MOMENT

A. J. E.—I notice that the sign of the bending moment for a simple beam is always positive, or +, and for a cantilever it is negative, or —; why is this, and what is meant by the negative sign?

A.—Fig. 1 represents a heavy beam of rectangular cross-section, supported at both ends as shown, thus representing to all intents and purposes a simple beam uniformly loaded. Let c be the center of gravity of the beam; then all the weight may be considered as concentrated at this point, and the effect produced by this weight is a bending of the beam as indicated in the illustration (greatly exaggerated). The dotted line (ab in A and bd in B) represents the neutral surface; and when the beam lies on a horizontal plane, this neutral surface is horizontal; the neutral surface always passes through the center of gravity of the cross-section. An examination of Fig. 1 shows that all longitudinal fibers of the beam above the neutral surface are in compression, due to bending, and all below the neutral surface are in tension, while those in the neutral surface are neither shortened nor lengthened—their lengths remain unchanged. Referring to Fig. 2, which represents a beam fixed at one end only, *i. e.*, a cantilever, an exactly opposite effect is produced; here the fibers above the neutral surface are in tension, and those below are in compression. Since the bending moments are measures of the effects just described, it is customary to call the bending moment of a simple beam positive, and of a cantilever, negative. The negative sign has no significance in so far as it affects calculations pertaining to the strength of beams; but it is useful and necessary in connection with investigations relating to restrained and continuous beams. It will also be noticed that the upper surface of the beam in Fig. 1 is concave, while in Fig. 2 it is convex; this is another reason for the opposite signs of the bending moments. J. J.

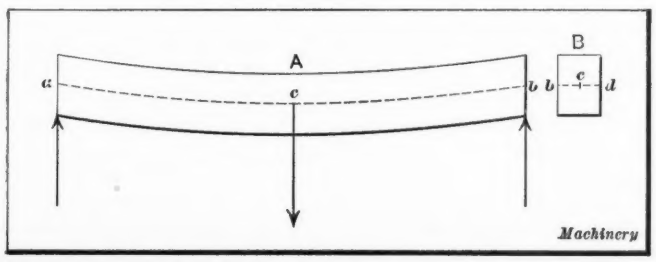


Fig. 1. Diagram showing Condition of Simple Beam subjected to Bending

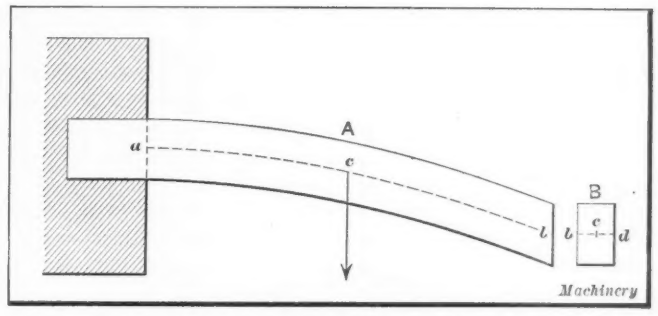


Fig. 2. Diagram showing Opposite Condition of Cantilever Beam subjected to Bending

CUTTING A SEMI-STEEL GEAR ON A MILLING MACHINE

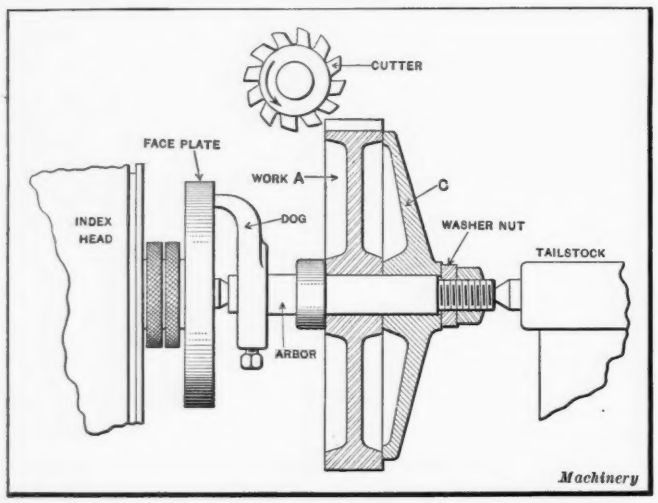
T. W.—Kindly give me an idea of what would be considered fair time to allow in cutting the teeth on a semi-steel spur gear of the following dimensions, giving the feeds and speeds which could be used on a No. 3 Cincinnati milling machine: gear sizes, 12.25 inches outside diameter, 2-inch face, 96 teeth, 8 pitch involute, whole depth of tooth, 0.270 inch, bore 1.25 inch.

A.—The material specified as semi-steel may vary greatly in hardness, so that it is difficult to give a definite feed and speed for this material without knowing its composition. Assuming, however, that the material is such that it can be cut at a speed of about 60 feet per minute for the roughing cut, with a normal amount of feed, the proposition would work out about as follows. The method used in setting up the gear itself is of considerable importance, as its diameter is such that unless it is properly supported a certain amount of chatter will be apparent and the speed must, therefore, be reduced, so that considerable loss of time will result. The accompanying illustration indicates a method which can be used for setting up a piece of work of this kind so that chatter will be avoided. The work A is held on an arbor which is supported on centers by the index head and suitably dogged, as indicated. A collar C can be used to support the portion of the gear which is being cut, so as to take the thrust of the cut and prevent chatter. The important point is to obtain a backing against which the cutter may work to its full capacity. In order to make a good commercial job, it would be necessary to take two cuts on each tooth, the first cut roughing out to within about 0.010 to 0.015 inch of the finished depth of tooth and the final cut bringing the work to the exact size.

The number of divisions or teeth to be cut being 96, it will be necessary to use differential indexing to obtain the proper division. The following settings would produce the desired result: index circle, 21; number of turns of crank, $\frac{9}{21}$; graduation on sector, 85; gear on worm, 28; gear on spindle, 32; idlers: No. 1 hole, 24; No. 2 hole, 44. The time necessary for setting up the machine would vary considerably and will not be taken into consideration in the estimate of time given herewith, for the reason that the number of gears to be machined is not known; hence, it would not be fair to consider the setting-up time in connection with this piece of work. The estimated time for the operation, assuming a cutting speed as mentioned and both roughing and finishing cuts on the teeth, is given herewith: diameter of rough stocking cutter, 2⅞ inches; cutting speed (rough), 60 feet per minute; revolutions of cutter per minute, 30; feed, 4 inches per minute; indexing gear and running back table for the cut on each tooth, 15 seconds.

In determining the amount of travel necessary for the cutter in cutting each tooth, it will be found that nearly 3 inches is needed to complete the cut, taking into consideration the approach of the cutter to the work when the latter is in the rough state. At a feed of 4 inches per minute and a distance to travel of 3 inches, 3/4 minute would be necessary to cut each tooth; the indexing and running back of the table after each tooth has been cut is estimated to be 15 seconds, which gives a total time necessary for cutting each tooth of exactly one minute. Hence, as there are 96 teeth to be cut, it will take 96 minutes to make the roughing cut on the gear.

For certain classes of work, a roughing cut might be all that is necessary, but in the majority of cases a finishing cut will be found advantageous. In finishing the work, the time consumed would be as follows: cutting speed, 80 feet per minute; revolutions of cutter per minute, 106; feed, 6 inches per minute; allowance for indexing and running back the table after each tooth is cut, 15 seconds. The actual length of time necessary to make the cut, therefore, is 1/2 minute, which, added to the 15 seconds allowed for indexing and running back the table, makes 3/4 minute for each tooth. Hence, $96 \times 3/4 = 72$ minutes. As the time for the first or roughing operation was found to be 96 minutes, and the second operation of finishing takes 72 minutes, the total time necessary for one



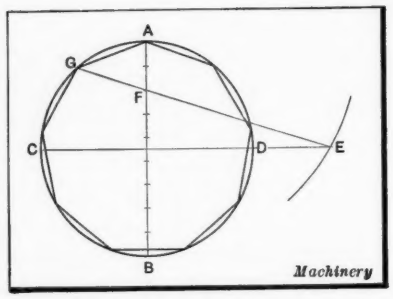
Set-up of Gear on Milling Machine

gear will be $96 + 72 = 168$ minutes, or 2 hours, 48 minutes, the total time necessary for cutting one gear of the size mentioned. It must be remembered that there is no setting-up time taken into consideration in this estimate, nor is there any allowance made for replacing the roughing cutter by the one used for finishing. The time given in the estimate, therefore, may be considered to be only the actual machining time with the incidental time necessary to perform the required movement of the table and index head. A man familiar with the machine and one well versed in this class of work might be able to make the necessary changes in the machine and set it up for the work in about an hour's time.

INSCRIBING POLYGONS IN CIRCLES

W. W. N.—Is there any rapid and accurate method for inscribing a regular polygon in a given circle? I want a general method, if possible.

A.—All general methods of inscribing a regular polygon in a circle are necessarily approximate, since, otherwise, it would be possible to square the circle, trisect an angle, and do other things that mathematicians have proved could not be done. The following construction is rapid, and is the best that is known to the writer; it is also sufficiently accurate to meet practically every need of the draftsman. Draw two diameters, *AB* and *CD*, at right angles to each other. Produce one of the diameters, as *CD*, and with one end of the other diameter, as *A*, as a center and a radius equal to the diameter, describe an arc cutting *CD* produced in *E*. Divide the diameter *AB* into as many equal parts as the polygon has sides, and through *E* and *F* (*F* is the second division point from *A*), draw *EF* cutting the circle at *G*. Then the chord *GA* is one side of the polygon, very nearly. For method of dividing *AB*, see the May number of MACHINERY, page 803. It is not necessary, of course, to draw in all the points of division, since only one, the point *F*, is needed. The figure shows how a regular polygon of nine sides may be inscribed. This construction is very accurate when the number of sides exceeds nine or ten; hence, if great accuracy is required, and the number of sides is less than nine or ten, it is better to inscribe a polygon of twice or three times the number of sides required. The desired polygon can then readily be drawn. J. J.



Inscribing a Regular Polygon in a Circle

TO FIND AREA OF ANY PLANE FIGURE

A. F. W.—Will you please give me a rule or method for finding the area of any plane figure, no matter what its shape?

A.—The two rules that are most frequently used for finding the area of a plane figure are the so-called trapezoidal rule and Simpson's rule; the latter is more accurate, but the former is a trifle easier of application. An actual example will make the process clear. Referring to the diagram, find the area included between the arcs *ABC* and *AGC*. First draw a line, either within or without the figure, but extending its entire length; in this case, the line *AC* will be the most convenient. Divide this line into any even number of equal parts, say ten, and through the points of division, draw perpendiculars to *AC;* these perpendiculars are called ordinates. The ordinates are lettered h_0, h_1, h_2 .... h_{10}, the end ordinates, h_0 and h_{10}, being equal to 0 in this case. Measure the ordinates very carefully; add those which have odd subscripts (as h_1, h_3, etc.) and multiply the sum by 4; add those which have even subscripts (as h_2, h_4, etc., but not including the end ordinates) and multiply the sum by 2; add the two products and the two end ordinates, multiply the sum by the distance between any two consecutive ordinates, and divide the product by 3; the result is the area by Simpson's rule. Expressed as a formula, the rule becomes

$$A = \frac{d}{3}\left[h_0 + h_{10} + 4(h_1 + h_3 + h_5 + h_7 + h_9) + 2(h_2 + h_4 + h_6 + h_8)\right]$$

in which d = the distance between any two consecutive ordinates = $AC \div 10$, in this case. As measured by the writer, the area is $A = 0.499 \div 3\ [0 + 0 + 4\ (0.83 + 1.73 + 2 + 1.73 + 0.83) + 2\ (1.37 + 1.93 + 1.93 + 1.37)\ ] = 6.93$ square inches.

By the trapezoidal rule, measure the ordinates half way between the equal division points (as *ab*, *cd*, etc.), find their sum, and multiply it by *d*, the distance between two consecutive ordinates. As measured by the writer, $A = 0.499\ (0.45 + 1.12 + 1.56 + 1.84 + 1.98 + 1.98 + 1.84 + 1.56 + 1.12 + 0.45) = 6.94$ square inches. By calculation, $A = 6.93$ square inches. Had the figure been *ABCDHE*, *AE* and *CD* being parallel to *O'O*, and the radius $OH = 3.5$ inches, the area by Simpson's rule would be 9.79 square inches; by the trapezoidal rule, 9.84 square inches; and by calculation, 9.78 square inches. By the trapezoidal rule, *AC* may be divided into any number of equal parts, but Simpson's rule requires an even number. J. J.

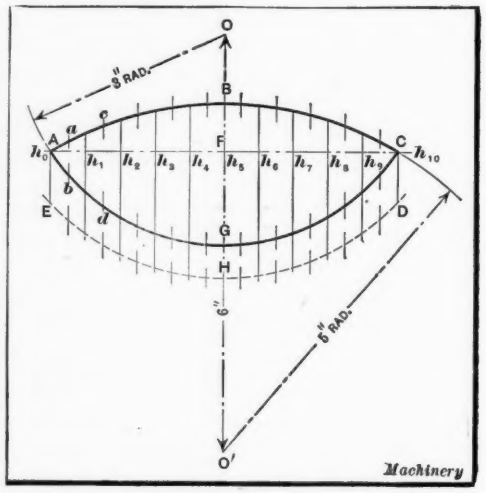


Diagram for finding Area of Any Plane Figure

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW AMERICAN METAL-WORKING MACHINERY

BAKER HEAVY-DUTY DRILLING AND BORING MACHINE

This machine is noteworthy because of its exceptional size. The maximum distance from base to spindle is 48½ inches; distance from center of spindle to face of frame, 22 inches; total height of machine, with the spindle in its highest position, 13 feet, 3½ inches; over-all width, 60 inches; and net weight, 18,000 pounds. The drive is through a single pulley and back-gears to the speed-box, eight changes of speed being available, covering a range from 3.5 to 87 revolutions per minute. Twelve changes of feed are provided which cover a range from 0.005 to 0.032 inch per revolution of the spindle. An interesting feature of construction is the liberal use which has been made of ball bearings, twelve sets of bearings being used in each machine.

Constant effort made by progressive manufacturers to increase their rates of production has resulted in great progress in the design of machine tools intended for operation at high speed. To meet the demand for drilling and boring machines having sufficient power and productive capacity to work at high speed on cast steel and forgings, Baker Bros., Toledo, Ohio, have added to their line the heavy-duty high-speed drilling machine which forms the subject of this article. Reference to Figs. 1 and 2 will show that it is of the vertical type with a column of box section which carries the spindle, feed-box and speed-box; this column is bolted to a heavy base casting which extends out to the front, forming a table in which seven 1¼-inch T-slots are cut. A hole is also bored in the center of the table to form a support for boring-bars, in addition to which the base carries pockets for cutting fluid. No other table is required for handling those classes of work for which this machine is adapted.

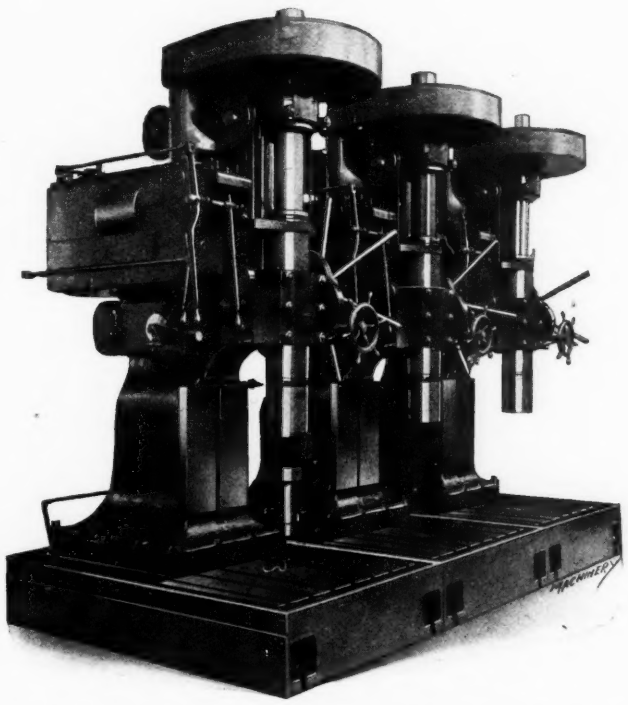


Fig. 1. Left-hand Side of Baker Drilling Machine, showing Speed- and Feed-boxes and Control Levers

Power is supplied by a 6-inch double belt which runs over tight and loose pulleys, 24 inches in diameter, that rotate at 400 revolutions per minute. The machine is started and stopped by shifting lever *A*, Fig. 3. From pulley shaft *D*, Fig. 4, power is transmitted through back-gears mounted on the frame to a speed-box shown in Fig. 3, which is mounted at the side.

Fig. 2. Right-hand Side of Baker Drilling Machine, showing Hand Feed, Feed Trip and Rapid Traverse

The double back-gears provide two speed changes, and four changes are provided in the speed-box. Power is transmitted from the back-gears to the speed-box through 2-pitch bevel gears, and in this connection it may be mentioned that the back-gears *E* and *F* are 5/7-pitch stub-tooth steel gears which are hardened and ground. Lever *C*, Fig. 3, is used for shifting the back-gears, and lever *B* operates through an H-control to give the four speed changes through sliding gears in the

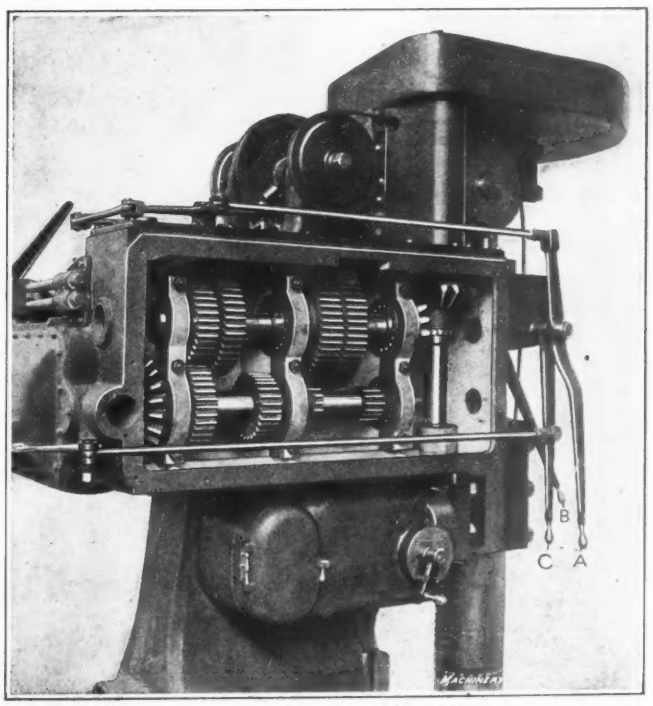


Fig. 3. Close View of Speed-box with Cover removed to show Gearing

speed-box. These are 4/5-pitch stub-tooth steel gears, which are hardened and ground, and supported on steel shafts similarly heat-treated. From the foregoing it will be evident that two levers provide eight changes of speed, which are 3.5, 5.5, 8.5, 13, 23, 36, 56 and 87 revolutions per minute. All shafts in the speed-box are mounted on S. K. F. ball bearings, of which twelve sets are used in each machine.

From the speed-box power is transmitted to the spindle through 2-pitch bevel gears and a driving shaft to spur gears mounted at the top of the machine. The spur pinion on this vertical shaft is a 2-pitch, 16-tooth gear of 5 inches face width

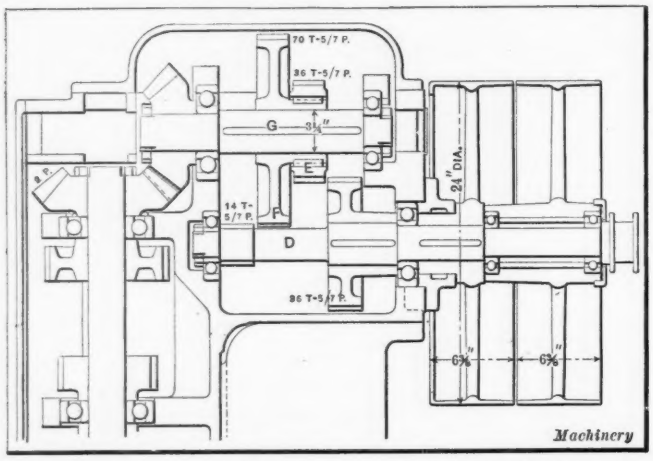


Fig. 4. Arrangement of Drive from Pulley Shaft through Back-gears

meshing with an 80-tooth main driving spindle gear. The teeth of this gear are cut in a steel shrouding bolted to a cast-iron hub by six ⅞-inch bolts. These gears are enclosed in an oil-proof housing and run in grease. The spindle is of forged open-hearth steel containing 0.60 per cent carbon; the maximum diameter is 10 inches and the minimum diameter, 7 inches. It is driven from the main driving gear through two 1¼-inch tool-steel feather keys located 180 degrees apart; and the end of the spindle is slotted 4 inches wide by 1 inch deep to provide for driving the tools. Owing to the extraordinary size of the spindle, standard tapers are not large enough, and so a special taper is employed. The hole is 9 inches deep by 4 inches in diameter at the bottom of the taper and tapers 0.625 inch per foot. The shank of the driving tool is held in place by a pin 1 inch in diameter, and at the end of the taper a drift hole 1½ inch in diameter is bored through the spindle instead of employing the customary slotted drift hole.

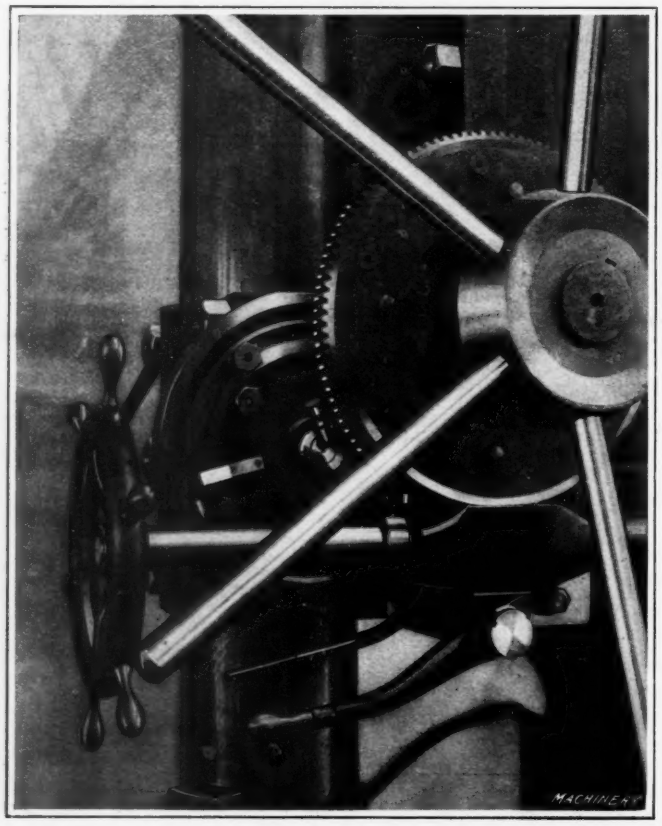


Fig. 5. Close View of Feed Trip Mechanism in Place on Machine

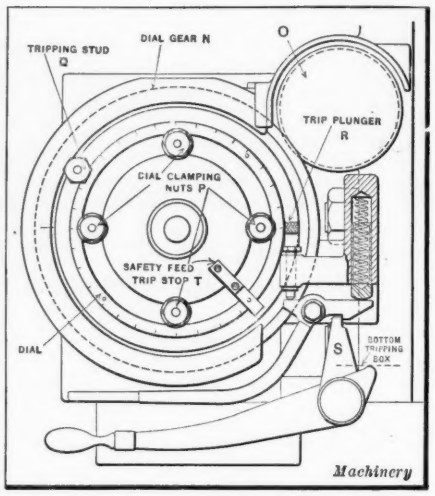


Fig. 6. Arrangement of Feed Trip Mechanism

The spindle thrust is taken by ball thrust bearings located at the top and bottom of the spindle quill. The balls are of a special alloy steel; in the bottom bearing they are 1¼ inch in diameter, while ¾-inch balls are used in the top bearing. The spindle quill is 10 inches in diameter, and it is made of cast steel and ground to size. Vertical feed is obtained through a rack and pinion, the rack teeth being milled from the solid quill, which has ¾-pitch stub teeth and provides a maximum vertical feed motion of 27 inches. Traverse of the spindle is effected by turning a six-handled capstan by hand.

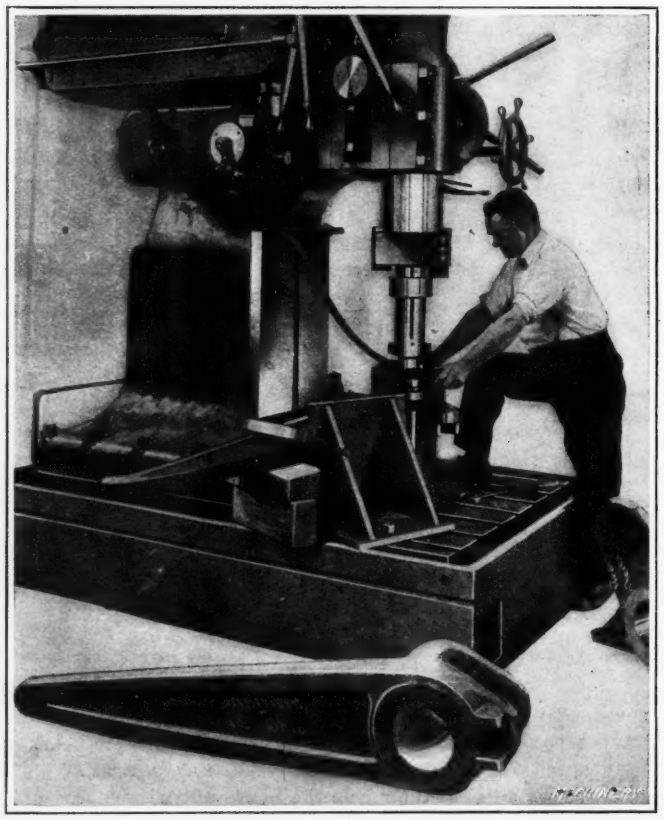


Fig. 7. Close View of Machine in Operation and Typical Example of Work

The quill is prevented from rotating with the spindle by two guide bars cast integral with the quill. In addition to preventing rotation, these guide bars carry the spindle counterbalance cables which support weights inside the frame of the machine. An idea of the size of the spindle will be obtained from the fact that the counterbalance weighs 1650 pounds. On smaller drilling machines built by Baker Bros. the quill carries the feed trip band, but on the present machine the feed band must necessarily be omitted because of clearances in design. An interesting tripping mechanism is employed for the automatic trip.

Power is transmitted from the vertical driving shaft and thence through a bevel gear and pinion to the feed-box. Four positions of a drive key with change-gears provide twelve changes of feed, which are 0.005, 0.006, 0.007, 0.008, 0.010, 0.012,

0.014, 0.016, 0.019, 0.023, 0.027 and 0.032 inch per revolution of the spindle. Any number of other feeds may be obtained by providing additional change-gears. From the feed-box a shaft is carried through the frame of the machine to connect with the feed worm and trip, and Fig. 6 shows the arrangement of this trip mechanism, to which reference has already been made. Dial gear *N* operates from feed pinion shaft *O* and is of sufficient size so that one revolution more than covers the 27 inches of vertical feed to the spindle. Within the dial gear—mounted and clamped in position by four bolts *P*—there is an adjustable dial plate graduated in divisions of 1 inch over a feed range of 0 to 27 inches. Trip stud *Q* may be set at any point on this dial plate, the trip stud being carried in a T-slot cut in the dial plate. As stud *Q* feeds around, it strikes the trip plunger *R*, which releases lever *S*, thus tripping the feed worm out of mesh with the worm-gear and releasing the feed. A safety stop *T* is provided which is set so that the feed is always tripped before the guide bars in the spindle quill strike the top of the lower spindle bearing. By loosening bolts *P* the dial plate can be set at any convenient point for the operator to set trip stud *Q*.

The principal dimensions of the machine are as follows: maximum distance from top of base or table to face of spindle, 48 inches; minimum distance from top of base or table to face of spindle, 21 inches; distance from center of spindle to face of frame, 22 inches; height of machine with spindle in highest position, 13 feet, 3½ inches; over-all width of single-spindle machine, 60 inches; and net weight of machine, 18,000 pounds.

CONTROL MECHANISM FOR ANDERSON DIE FORMER

In the October, 1915, number of MACHINERY a description was published of the die forming machine which had just been placed on the market by the Anderson Die Machine Co., 590 Water St., Bridgeport, Conn. The general features of design were the same as those of the machine shown in the illustrations accompanying the present article, but recently an improved form of control mechanism has been developed, which enables greater accuracy to be obtained in finishing the sides of a die or similar piece of work than was possible with the original machine. The chief object of this device is to make it possible to machine straight surfaces in the die and have these surfaces at any desired angle to other surfaces in the die.

Referring to Fig. 1, which shows a plan view of the machine, it will be seen that there is a dovetail *A* along one side of the table, on which is carried a block *B*. Secured to this block is a guide *C* that slides over the table surface as the position of block *B* is changed by turning knurled nut *D*. Guide *C* is held at right angles to the edge of the table and is grooved to support rod *E*, the position of which may be changed by turning knurled nut *F*. Block *G* rides on the outside of

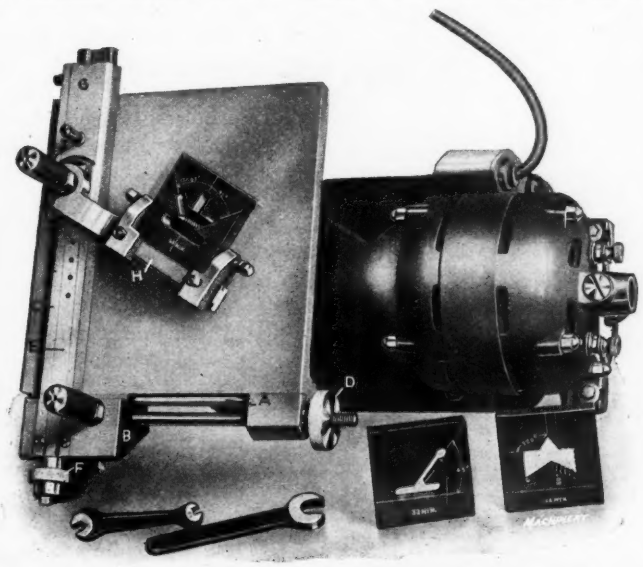


Fig. 1. Plan View of Anderson Die Former, showing Arrangement of Controlling Mechanism

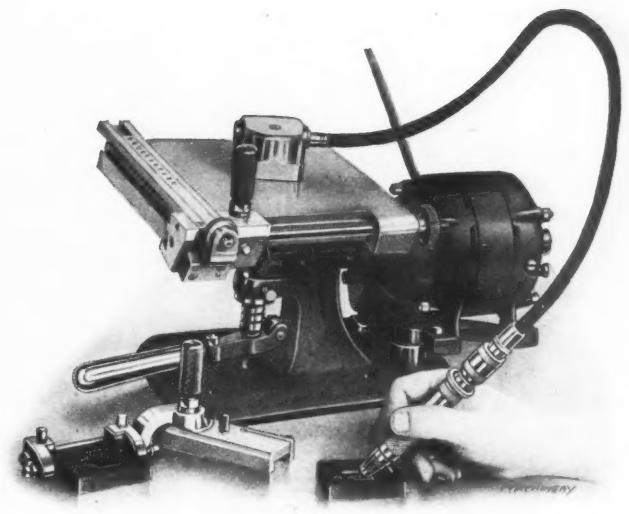


Fig. 2. Anderson Die Forming Machine with Flexible Shaft Connection to Tool

guide *C* and supports die-holding clamp *H* in the manner illustrated. Block *G* and die-holder *H* are secured to adjustable rod *E* by inserting pin *J* in one of the holes in this rod; and it will be noticed that set-screws provide for locking block *B* to dovetail slide *A*, and block *G* to slide *C*, respectively.

It will be evident that when a die-block has been set up in holder *H* and set-screws loosened so that blocks *B* and *G* are free to move on their respective guides, a suitable adjustment of screw *D* or *F* provides for feeding the die-block up to the cutter ready for taking a cut of the desired depth. After this preliminary setting has been made, the cut is taken by sliding block *B* on dovetail *A* or block *G* on guide *C*, as the case may be. After taking a cut in this way, the work is brought back to the starting point, after which the knurled screw is manipulated to feed the work to the cutter, ready for taking a second cut, and so on until the operation has been completed.

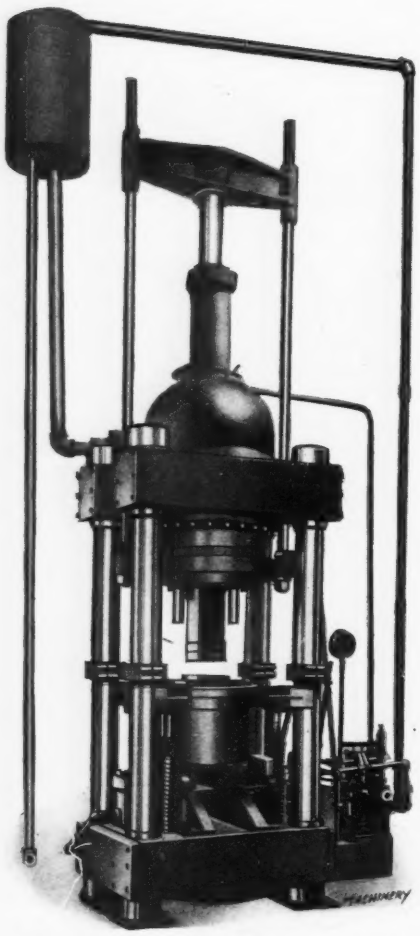
HYDRAULIC BRIQUETTING PRESS

The accompanying illustration shows a new hydraulic press recently brought out by the Hydraulic Press Mfg. Co., 84 Lincoln Ave., Mount Gilead, Ohio. The press is used for briquetting metal borings, turnings, etc., so that they may be remelted without the loss of valuable constituents and without oxidizing; and it also puts the material in a convenient form for handling. This press is of the four-rod inverted cylinder type, and is built in three different sizes with pressure capacities of 1000, 750, and 300 tons, respectively. The illustration shows the 1000-ton press.

The briquet forming mechanism of these presses is capable of quickly forming a briquet of uniform density. This is accomplished by placing the material in a floating mold supported by four springs. When the pressure is applied from above, the friction of the material on the sides of the mold causes it to move down over a stationary plunger which projects into the mold from below. Pressure is thus applied on the bottom as well as on the top of the material, and a briquet of uniform density is obtained.

After being formed, the briquet is ejected from the mold by pressure of the main ram applied upon the briquet with the lower plunger removed, the latter being effected by a simple movement of a controlling lever. The briquet then falls through to the base of the press, whence it is removed by a conveyor. On the 1000- and 750-ton presses, hydraulic push cylinders lift the floating mold while the lower die is withdrawn or returned to place. A collar surrounding the lower die is held against the mold by a spring to close up all clearance between the mold and the lower die in the 300-ton press.

The press here illustrated is provided with a surge tank, the base of which is located higher than the main cylinder. By a simple movement of the valve lever, the plunger drops to the material in the mold and the main cylinder is filled



Hydraulic 1000-ton Briquetting Press for Metal Borings and Turnings

with fluid by suction caused by lowering the ram as well as by action of gravity on the fluid. Thus the first stroke of the pump initiates the pressure upon the material. After completing the pressing operation, the main ram is returned by means of the auxiliary ram located at the extreme top of the press, and, as will be readily seen, this action returns the fluid to the surge tank.

Every operation of these presses is controlled by conveniently located levers. The stationary plunger projecting into the mold from below is displaced and replaced by a lever near the operating valve. The presses are solidly built, steel being used throughout. The strain rods are made of heat-treated forged steel, and they have solid heads and collars. The main ram is guided in its travel by babbitted bearings working upon the strain rods and by a long bearing in the throat of the cylinder; the floating mold is also guided by babbitted bearings. The collars located on the center of the strain rods prevent the floating mold from ascending too high.

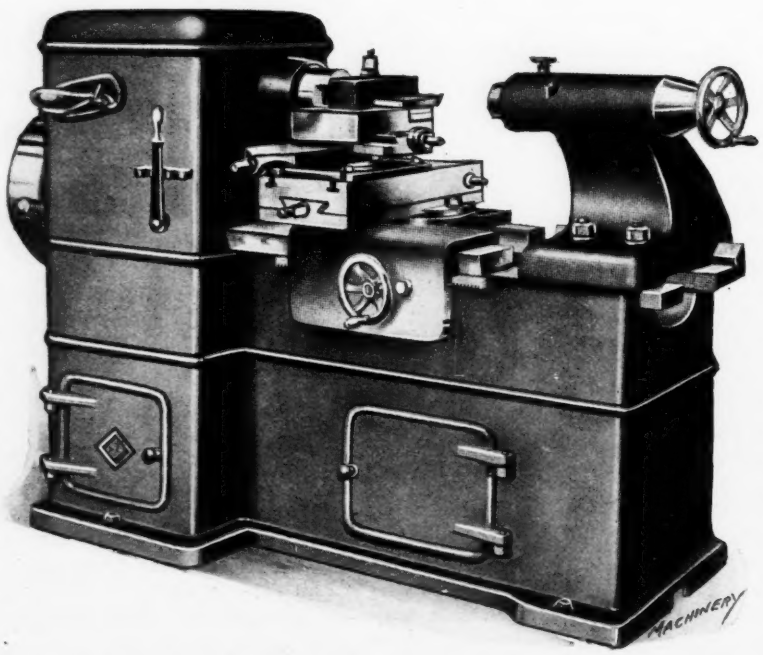
HAWES BELT POLISHING LATHE

The "Safety First" No. 12 vertical polishing machine which forms the subject of the following description is a recent product of C. L. Hawes, Ashtabula, Ohio. It will be seen that the base is designed along similar lines to that of the Hawes grinder and polisher; but two pulleys have been substituted in place of the grinding wheels, and overhead works furnished to support two upper pulleys for carrying two endless polishing belts. Provision is made for maintaining the required belt tension by means of two small handwheels that enable the upper pulleys to be raised to take up any slack that develops in the belts. These polishing belts may be from ½ to 2½ inches in width, and the pulleys may be run at speeds up to 4000 revolutions per minute. The illustration shows a belt-driven machine, but provision may be made for the application of electric motor drive, in which case a two-horsepower constant-speed motor is employed. The floor space occupied by the machine is 36 by 24 inches. The machine is 6 feet high and weighs approximately 1000 pounds.

Hawes No. 12 "Safety First" Vertical Polishing Machine

CLEVELAND CUTTER RELIEVING MACHINE

The Cleveland Milling Machine Co., 18511 Euclid Ave., Cleveland, Ohio, is now building the cutter relieving machine illustrated and described herewith. This machine has been developed for the special purpose of relieving formed cutters up to 13½ inches in diameter with any number of teeth from one to twenty-eight, inclusive, and any even number of teeth from twenty-eight to forty-two, inclusive, giving straight, side or end relief on all cutters that come within the capacity of the machine. It will be noted from the illustration that box-type construction has been adopted for all large members, including the base, bed, headstock and tailstock, in which the metal is generously distributed in both the walls and webs to provide ample strength.



Cleveland Cutter Relieving Machine for giving Straight, Side or End Relief to Teeth

Power is provided by a 14-inch pulley which carries a 3-inch belt and runs at 460 revolutions per minute. From this pulley the drive is through a set of reverse gears to a tumbler pinion, from which five selective spindle speeds are obtained, the drive being transmitted through a

worm-wheel of large diameter, mounted directly upon the spindle. The machine can be started, stopped or reversed by manipulating a single hand-lever. The spindle is machined from a high-carbon steel forging and is 3½ inches in diameter at the largest point. It runs in solid tapered phosphor-bronze bearings, provided with means of compensating for wear. The taper hole in the spindle is No. 10 Brown & Sharpe, and the spindle is bored to accommodate a 1-inch draw bolt.

The tailstock sleeve is 2½ inches in diameter and is bored No. 10 B. & S. taper; it has a maximum adjustment of 7 inches by means of a handwheel. Alignment of the tailstock is maintained through one 90-degree V-way at the back of the bed, the flat bearing at the front being 2 inches wide by 15 inches in length. The tailstock may be locked in any desired position by two clamping bolts located in front of the tailstock. The rear carriage bearing is 3 inches wide and the front bearing 6 inches wide; the carriage is gibbed longitudinally to the front bearing and the apron is cast integral with the carriage. The carriage is provided with a maximum longitudinal adjustment of 13 inches, which is obtained by operating a handwheel. Each complete single turn of this wheel gives a longitudinal carriage movement of 1 inch.

A single throw cam giving relief from 0 to ¾ inch is carried by a cam slide swivel plate which is adjustable to any degree desired. Tapered gibs are provided for taking up wear on all slides. The forming tool may be quickly positioned in the proper relation to the cutter by means of a double adjustable toolpost graduated to 0.001 inch. Corrugated adjustable wedges on top of the toolpost provide for adjusting the amount of stock that is ground off the forming tool from ¾ to ¼ inch. This cutter relieving machine may be motor-driven, if desired, in which case a three-horsepower constant-speed motor is mounted on top of the headstock. The weight of the machine is approximately 7000 pounds.

"PRODUCTION" HAND SURFACE GRINDER

The "Production" hand surface grinder which forms the subject of the following description is a recent product of the New Jersey Machinery Exchange, 21 Mechanic St., Newark, N. J. In designing, an effort was made to make this machine as simple as possible and still adapt it for grinding and finishing flat surfaces on punches, dies and machine parts. By referring to the accompanying illustration, it will be seen that the spindle is carried by a vertical slide which has a maximum movement of 7 inches and is operated by a handwheel that has a dial graduated to 0.001 inch. The spindle is carried in taper bearings and is provided with means of compensating for all ordinary wear.

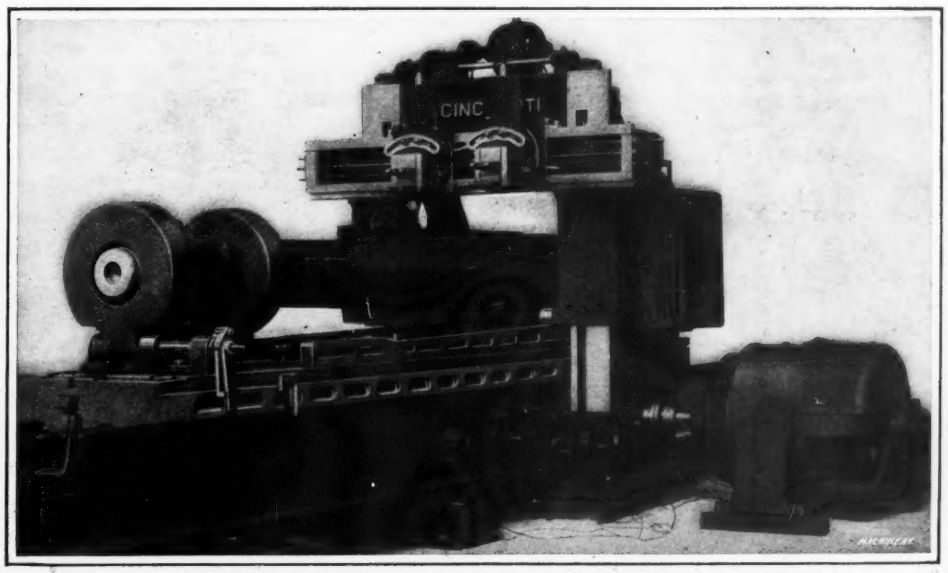
"Production" Hand Surface Grinder built by New Jersey Machinery Exchange

Longitudinal and transverse movements are provided for the table, the latter being operated by a handwheel fitted with a dial graduated to 0.001 inch, which is similar to the vertical feed. Longitudinal movement of the table is obtained by means of a hand-lever so proportioned that a quick and accurate movement is obtained for the work. The slides for both these movements have liberally proportioned bearing surfaces and are fitted with gibs to compensate for wear. The slides are so designed that it is impossible for grit to find its way into the bearings. This grinder is driven by a countershaft with a weighted idler pulley which maintains a constant belt tension. For average classes of work a countershaft speed of 400 revolutions per minute is recommended.

The principal dimensions of the "Production" hand surface grinder are as follows: size of table, 15 by 5 inches; maximum traverse of table, 8 inches; maximum cross-feed, 6 inches; maximum vertical adjustment of spindle slide, 7 inches; maximum distance between wheel and table, 6 inches; size of grinding wheel, 6 inches in diameter by ½ inch face width; width of driving belt, 1½ inch; diameter of countershaft tight and loose pulleys, 4½ inches; width of countershaft driving belt, 2 inches; speed of countershaft, 400 R. P. M.; and weight of machine, 435 pounds.

CINCINNATI GUN BARREL PLANER

The Russian 9.2-inch howitzers have a projecting guide extending along each side of the barrel, which allows the barrel to move back in the carriage to absorb recoil. The presence of these guides makes it impossible to turn the barrels on a lathe, and to provide for machining them the Cincinnati Planer Co., Cincinnati, Ohio, has built a number of special 48- by 48-inch by 18-foot planers, one of which is shown in the accompanying illustration. These planers are driven by a reversible motor drive coupled direct to the machine. The howitzer barrels are first turned on the outside wherever the projecting guides do not interfere, and one end is also turned to fit the chuck while a plug center is put in the opposite end to align the work properly. After this has been done the barrel is



Cincinnati Planer for machining 9.2-inch Russian Howitzer Barrels

mounted between centers on the planer table and completely finished between the projecting guides which are also planed while the gun barrel is set up on the planer.

It will be seen that the front center or headstock is provided with an expansion chuck which is part of the spindle, on which a large worm-wheel is mounted at the opposite end. The worm that engages this wheel is keyed on a shaft that has a ratchet lever mounted at its outer end; and this ratchet lever engages a tappet fastened at the side of the bed to provide for revolving the gun barrel for the next stroke after each cut has been completed. The cross-rail, which has a sliding fit on the housings, is provided with two brackets bolted under the rail and further held by a clamp on both the outside and inside. A roller is mounted on each of these brackets at the lower end, and projects over the side of the table to engage a cam, the contour of which corresponds exactly to that which is required on the gun barrel.

The operation of this machine differs but little from that of a standard planer except for the feed and taper attachment. The table is started on its cutting stroke in the regular way, and the cross-rail, instead of maintaining a fixed position, is guided by rollers contacting with the forming cams on the table to cause the cross-rail to rise and fall as the table passes under it, thereby giving the required taper form to the work. At the end of the return stroke the ratchet lever on the worm-shaft strikes the tappet at the side of the bed, causing the lever to rotate through an arc and give the worm-wheel the necessary movement to revolve the work through an angle corresponding to the required feed. It will be noted that this combination of two motions, *i. e.*, turning the gun on center at the end of each stroke and raising or lowering the cross-rail while the table is in motion, causes the tool to plane both a circular cross-section and a tapered longitudinal section for the gun barrel. When planing the straight rectangular recoil guides the cross-rail is raised a little so that the rollers are clear of the cams and bolted fast to the housings; the ratchet lever is also disengaged and the feed obtained through the regular feed gears at the end of the cross-rail.

HOLMES FILING MACHINE

The Holmes Mfg. Co., Shelton, Conn., is the manufacturer of the filing machine shown in the accompanying illustrations. A noteworthy feature of the design is that variable-speed drive is provided by a friction disk and wheel best shown in the rear view of the machine illustrated in Fig. 2. An Oldham coupling is employed to make connection between the driving motor and shaft on which the friction wheel is carried, as can be seen in the illustrations.

Another noteworthy point is that plain files can be used in the machine, making it unnecessary to obtain files with special shanks. General practice in the design of die filing machines has been followed by providing means of tilting the table to enable the necessary clearance to be filed in dies. In addition, special means have been furnished to enable the filing of punches to be performed in an expeditious manner. This is done by having the bar at the back of the machine, which supports the upper end of the file, sufficiently heavy so that a short file can be given plenty of support by simply holding it at the upper end. In this way a punch may be placed on the table and the file set so that it is able to file down close to a shoulder, as when filing the shank of a punch. This machine has four take-up bearings, and the stroke can be regulated from 0 to 1½ inch. The machine is portable, and can be carried to the work.

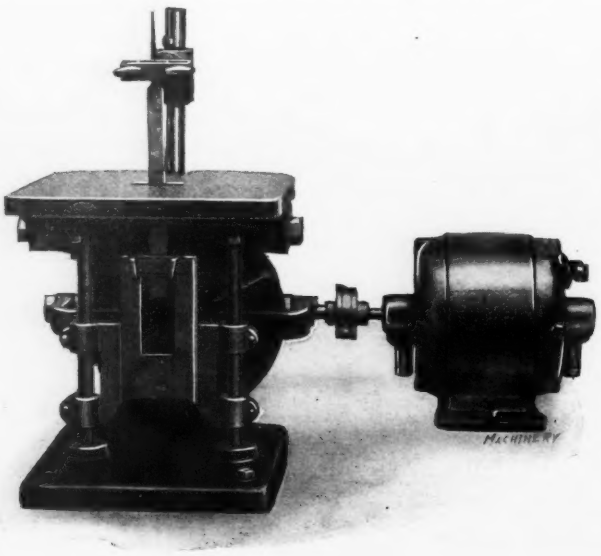


Fig. 1. Front View of Filing Machine built by Holmes Mfg. Co.

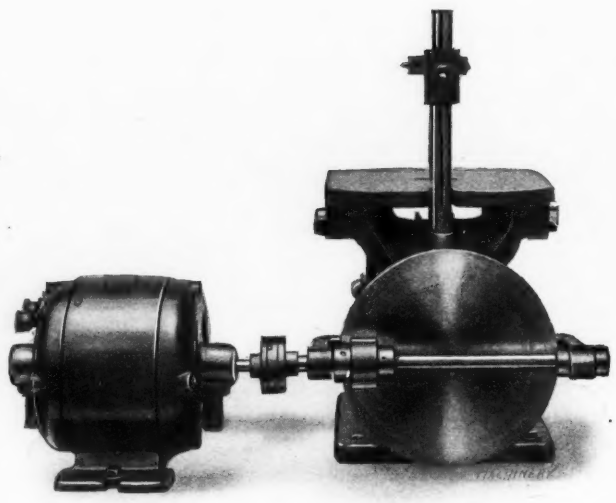


Fig. 2. Rear View of Holmes Filing Machine, showing Variable-speed Drive

FITCHBURG 8-INCH "LO-SWING" LATHE

The general features of design of this machine are similar to those of the well-known Fitchburg "Lo-swing" lathes, but the present machine is of much larger size, having a capacity for handling work up to 8 inches in diameter by 84 inches in length. Machines with longer beds can be built to meet special requirements. Connection between the feed-rod and carriage is made by an Oldham coupling which makes the carriage entirely independent of accuracy of alignment of the feed-rod. The drive is through a single 20-inch pulley which runs continuously, and no countershaft is required; the driving pulley is provided with a clutch operated by a shipper bar extending the full length of the machine. A pump is provided for supplying lubricant to all tools through supply pipes and thence through individual tubes to the cutting points of the tools. Under test in turning spindles from 50-point carbon steel, the machine removed 19.31 cubic inches of metal per minute.

The Fitchburg Machine Works, Fitchburg, Mass., have recently brought out a "Lo-swing" lathe of much larger capacity than previous types, and with different operating mechanism, although the machine has been designed after the "Lo-swing" principle, *i. e.*, that of turning different diameters and tapers with multiple tools operating simultaneously. The machine shown in Fig. 1 handles work up to 8 inches in diameter and will take shafts 84 inches in length or less, but machines with longer beds can be furnished to meet special requirements.

Bed and Carriage Construction

Fig. 2 illustrates the carriage mechanism and the bearings of the carriages upon the bed. It is one of the "Lo-swing" principles to place the carriages on the ways on front of the bed, and the tailstock and steadyrest on the back ways, thus permitting the carriages to pass both tailstock and steadyrest without interference. As may be seen in this illustration, the carriages are mounted on single heavy double-angle ways and each carriage is gibbed at the bottom to provide for taking up wear. An important feature of the carriage construction is the entire independence from alignment with the feed-rod that may be seen passing through the two carriages at the front of the

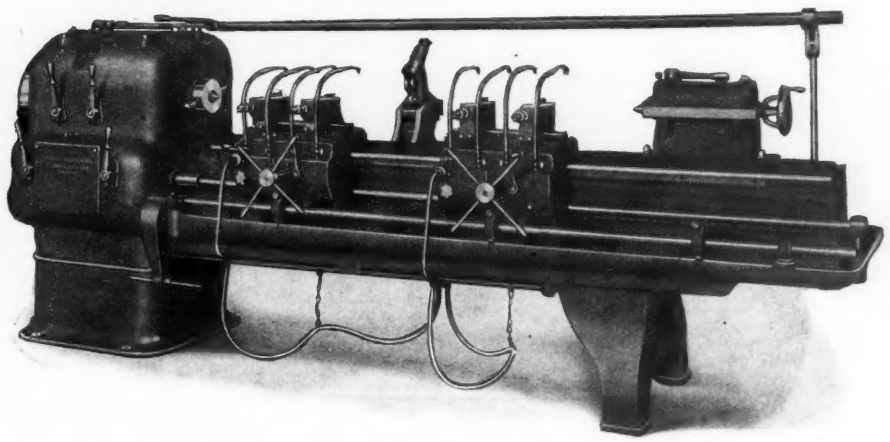


Fig. 1. Front View of Fitchburg 8-inch "Lo-swing" Lathe

machine in Fig. 1. Connection between the feed-rod and carriages is made through an Oldham coupling.

The feed driving gear is a double spur gear, and for forward movement of the carriage the right-hand section meshes directly with a sliding gear *E* on the worm-shaft *F*. For reverse movements of the carriage, the drive is through the left-hand section of gear *D* into the intermediate pinion *G* (best shown in Fig. 2) and then into the worm-shaft pinion *E*. Worm-shaft *F* carries a single right-hand steel worm *H* that meshes with bronze worm-wheel *I* on the capstan shaft *J*. The familiar type of worm-box construction is used, permitting of engaging or disengaging the feed by dropping the worm from the worm-wheel, when stops on the stop-rod shaft trip the feed or when the feed is tripped by a hand-lever.

On the forward end of capstan shaft *J* is pinion *M* meshing with a large spur gear on the rack pinion shaft; and on the right-hand end of this rack shaft is a pinion that meshes with the rack on the under side of the bed of the machine, as may be seen in Fig. 1. The carriages are provided with locks to hold them stationary while necking in for shoulders on shafts. The carriage tool-holders are not shown in Fig. 2, but two are shown on each carriage in Fig. 1. These hold tools of ¾ by 1¼ inch and may be independently adjusted to or from the work and longitudinally on the carriage. This is one of the standard "Lo-swing" principles.

Lever *Q* is for throwing the worm-box and worm into mesh through the bellcrank and link shown; and the worm is thrown out of mesh by pressing lever *R* in either direction. In operation, when the carriage reaches the location of a feed trip dog, the worm-box is disengaged by the throwing over of lever *S* that allows the worm-box to drop. After it has dropped the carriage may be moved a small amount by hand until it comes up solidly against the positive stop-screw *K* which absolutely limits the carriage travel. Reversal of the carriage is secured by sliding lever *U* along in the direction desired to operate the carriage, and this lever may be operated without stopping the feed. Lubrication of the carriage mechanism is through oil tubes leading from the front of the carriage to all the principal bearings.

Tailstock and Steadyrest

As may be seen in Fig. 1, the tailstock is of extremely heavy design and it operates on the back ways of the machine, being entirely independent of the carriages which may pass it without interference. The tailstock spindle is 17½ inches long and is operated by a handwheel. The end of the tailstock is fitted with a No. 4 Morse taper center. The tailstock spindle may be clamped in any desired position with a hand-lever. The steadyrest, used in turning shafts of small diameter under heavy cuts, clamps on the back ways and is fitted with roller supports.

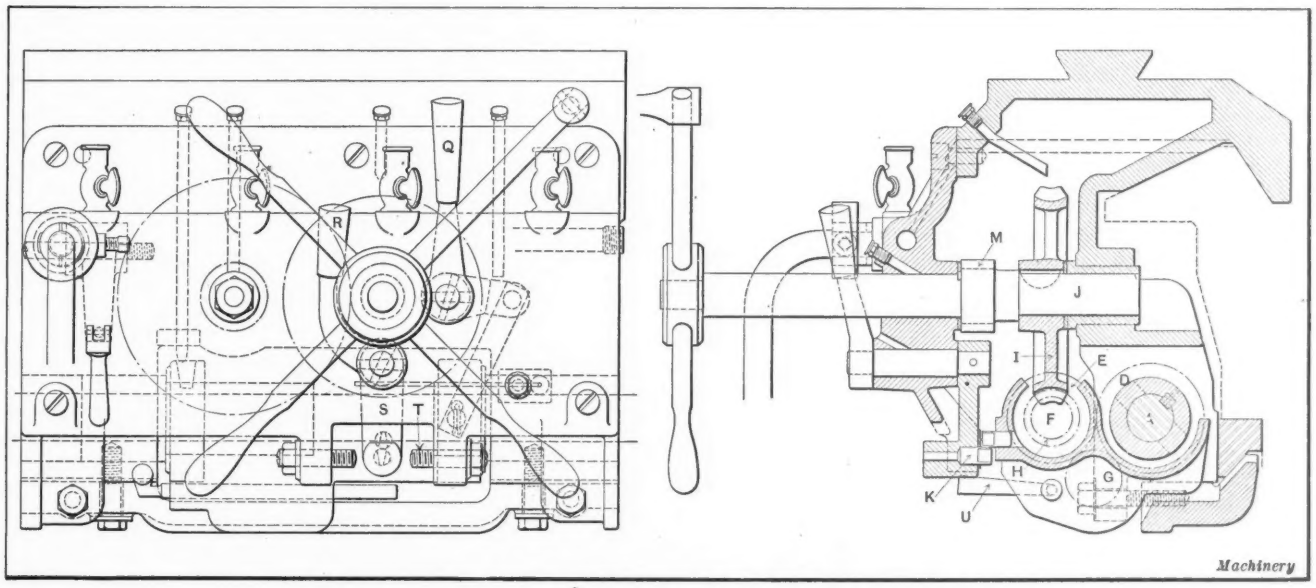


Fig. 2. Arrangement of Carriage Mechanism on Fitchburg 8-inch "Lo-swing" Lathe

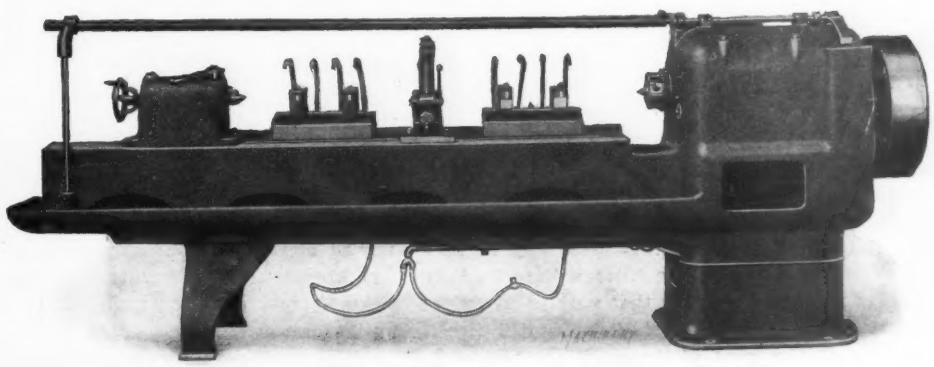


Fig. 3. Opposite Side of Fitchburg "Lo-swing" Lathe shown in Fig. 1

Driving Mechanism of Headstock

The drive is through a single 20-inch or 24-inch pulley, as desired, which runs continuously. No countershaft is required, as the pulley runs free on the driving shaft and is clutch-operated when it is desired to start the machine. A long shipper bar may be seen running the full length of the machine, and it is through this means that the clutch is operated. The clutch is toggle-operated and the drive is secured by clamping the loose driving pulley between flanges that are keyed to the driving shaft. This drive or pulley shaft is of large diameter and runs in bronze bearings. Six spindle speeds are available from the pulley shaft, three being obtained from the pinion on the pulley shaft and three from the clutch gear. When the drive is through the pinion, the clutch gear is disengaged; and when the drive is through the clutch gear, the latter is locked to a clutch plate keyed to the pulley shaft.

Referring to Fig. 1, the various levers for operating the feed and speed changes may be seen. The two upper levers are for the six spindle speeds. The left-hand lever operates a clutch on the spindle giving three speeds according to its location to the right, left or center. The right-hand lever operates the pulley shaft clutch gear, and this has two positions, right or left, thus compounding the speeds to give the six spindle speeds. Referring to Fig. 4, the various combinations of the clutch levers are shown at the left, and the resulting speeds that may be given to the spindle are shown. The spindle runs in adjustable bronze bearings with roller end thrust, and carries on the front end the "Lo-swing" balanced driver. The speed gears in the headstock all run in oil.

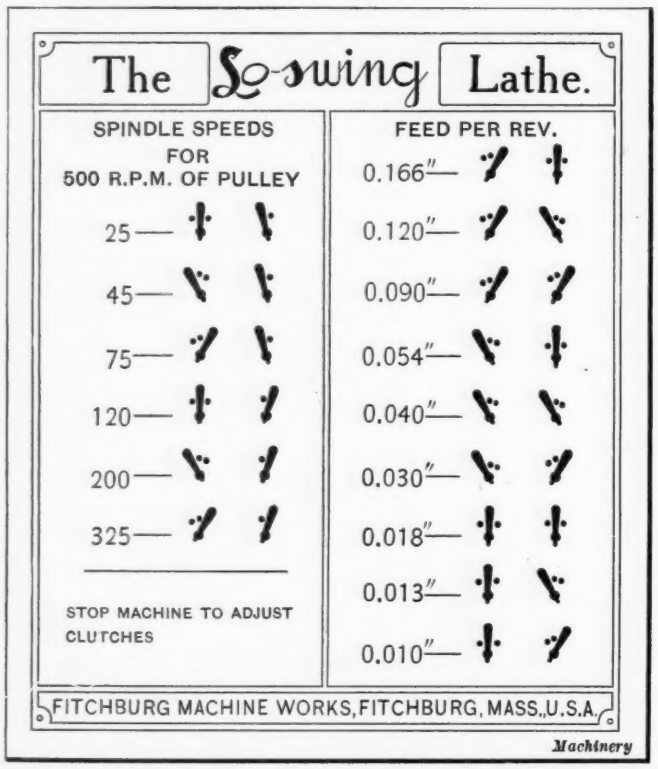


Fig. 4. Plate showing Lever Positions and Available Speed and Feed Changes

Feed Changing Mechanism

The feed is taken from a spur gear at the extreme left-hand end of the spindle, which operates through an idler gear and then through a gear on the upper feed shaft. This upper shaft has three feed gears of different diameters that may be meshed alternately with a three-step shoulder gear sliding on the lower feed shaft, thus giving three feeds to the lower feed shaft. The lower feed shaft has a three-step shoulder gear at the right-hand end, and this gear may be meshed with any one of three gears on the intermediate feed shaft, making a total of nine feed changes that may be given the intermediate shaft. This intermediate shaft is coupled directly to the main feed-rod at the front of the machine.

The nine variations of feed for the feed-rod are shown at the right-hand side of Fig. 4. This illustrates the position of the two levers for securing any rate of feed from 0.166 inch per revolution to 0.010 inch per revolution in geometrical progression. These two levers are the ones shown at the lower part of the headstock in Fig. 1.

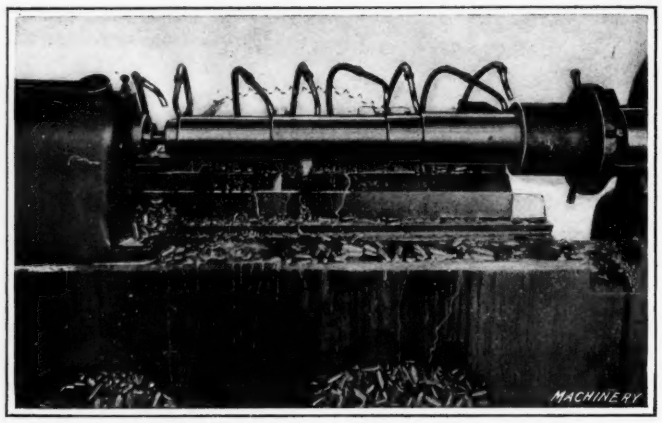


Fig. 5. Tooling used for turning Spindles on Fitchburg Lathe

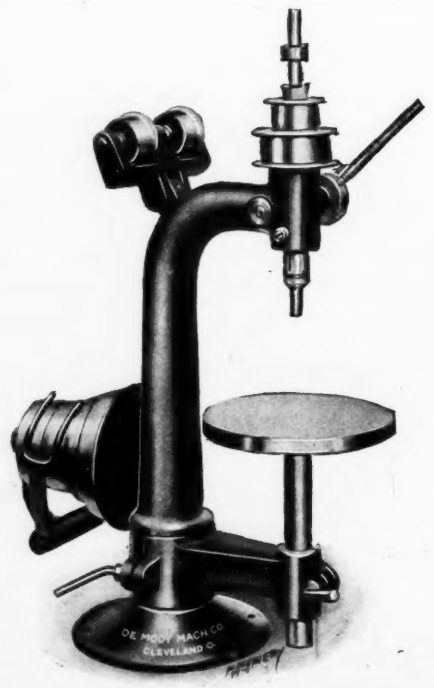
Lubrication

The pump for supplying the lubricant to the cutting points of the carriage tools is located in the base of the head and is operated by bevel gearing from the end of the pulley shaft. Thus lubrication is provided for the tools whenever the machine is in operation. Lubricant comes through the supply pipes to each carriage and thence through individual tubes to the cutting points of the tools.

An interesting set-up is the turning of a steel spindle for a lathe, shown in Fig. 5, that illustrates the character of the work that the machine can do. This shaft is 36½ inches long and is made of fifty-point carbon steel. At the first setting five tools are employed, the first of which takes a cut 1 inch deep, the second ⅛ inch deep, the third ⅛ inch deep, the fourth 3/16 inch deep, and the fifth 3/16 inch deep. When all five tools on this operation are at work, as shown in Fig. 5, a total depth of cut of 1⅝ inch is being taken, which means removing 3¼ inches stock from the diameter. As the outside stock diameter is 6¼ inches and the finished diameter is 3 inches at the small end, it is obvious that the diameter is being reduced by 3¼ inches when all five tools are cutting. The shaft is turned at 45 revolutions per minute, and the feed is 55 turns to the inch. 19.31 cubic inches of metal is removed per minute, finishing the shaft complete for grinding, except the head, at one operation in forty-two minutes.

DE MOOY BENCH DRILLING MACHINE

The De Mooy Machine Co., 1833 E. 55th St., Cleveland, Ohio, has recently placed on the market the 10-inch sensitive drilling machine illustrated and described herewith. This machine has a plain spindle bearing and is adapted for spindle speeds up to 1300 revolutions per minute. It will be seen in the illustration that the column and base are cast integral, the casting being of box section and composed of high-grade gray iron. The belt shifter is attached to the cone shaft bracket and may be shifted to conform to the angle at which the machine is driven. The table and pulley bearing sleeves are ground to in-



De Mooy Sensitive Bench Drilling Machine

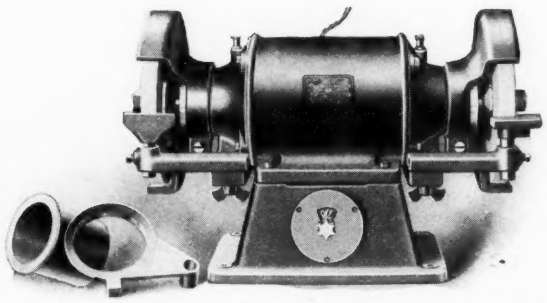


Fig. 1. Hisey-Wolf Bench Grinder built with One-half-horsepower and One-horsepower Motors

sure accurate fits. This machine has been designed with the view of making all parts as simple as possible.

These bench drilling machines are built in two sizes, known as Nos. 1 and 2, respectively. The principal dimensions of the No. 1 machine are as follows: maximum distance from spindle to table, 7½ inches; maximum vertical movement of spindle, 2¼ inches; maximum vertical movement of table, 6 inches; diameter of table, 8¼ inches; distance from center of spindle to frame, 5¼ inches; drilling capacity, for holes up to 5/16 inch in diameter; size of tight and loose pulleys, 4 inches in diameter by 1½ inch face width; speed of driving pulley, 550 revolutions per minute; height of machine, 24 inches; floor space occupied, 21 by 9 inches; and net weight of machine, 60 pounds. The principal dimensions of the No. 2 machine are: maximum distance from spindle to table, 12 inches; maximum vertical movement of spindle, 3½ inches; maximum vertical movement of table, 7 inches; diameter of table, 11½ inches; distance from center of spindle to frame, 7½ inches; drilling capacity, for holes up to ½ inch in diameter; size of tight and loose pulleys, 5 inches in diameter by 1⅝ inch face width; speed of driving pulley, 550 revolutions per minute; height of machine, 34 inches; floor space occupied, 26 by 13 inches; and net weight of machine, 110 pounds. The No. 1 machine has a taper spindle to fit a small drill chuck, while the No. 2 machine has a No. 1 Morse taper hole in the spindle.

HISEY-WOLF ELECTRIC GRINDERS

The accompanying illustrations show bench and floor grinders which constitute a recent addition to the line of machines built by the Hisey-Wolf Machine Co., Cincinnati, Ohio. It will be apparent from the illustrations that the machines shown in Figs. 1 and 3 are of essentially the same design with the exception of the fact that Fig. 1 shows a bench type machine while in Fig. 2 a similar head has been mounted on a column to make a floor type of machine. These grinders are built with ½-horsepower and 1-horsepower motors for either alternating or direct current. In the alternating-current type, ½-horsepower machines run at 3400 R.P.M., and the 1-horsepower machines at 1750 R.P.M. In the direct-current type, ½-horsepower machines are adapted for speeds of 3000 R.P.M., and the 1-horsepower machines 2100 R.P.M. With the exception of height and weight, the principal dimensions of both bench and floor type machines are the same. For the ½-horsepower machines these dimensions are as follows: size of grinding wheels, 8 inches diameter by ¾ inch face width; diameter of spindle at wheel mounting, ⅝ inch; and distance between wheel centers, 16 5/16 inches. For the 1-horsepower machine, the principal dimensions are: size of grinding wheels, 10 inches diameter by 1 inch face width; diameter of spindle at wheel mounting, ¾ inch; and distance between wheel centers, 21⅛ inches. The direct-current machines are furnished with 110- or 220-volt motors, and the alternating current machines with 110-volt, 60-cycle, ten-phase or 220-volt, 60-cycle, one-, two-, or three-phase motors.

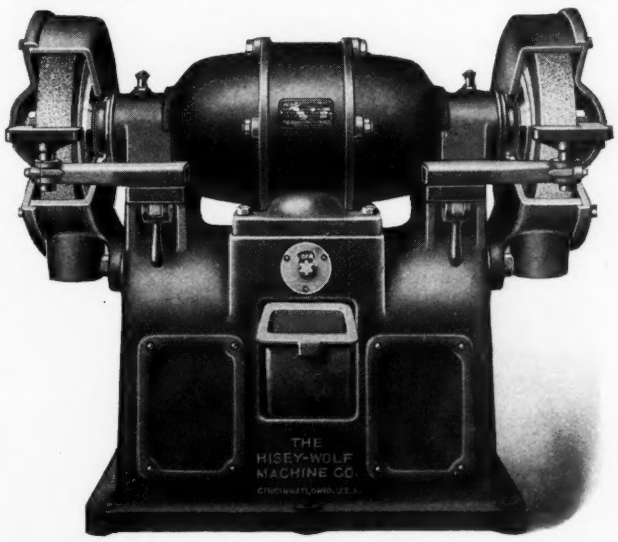


Fig. 2. Hisey-Wolf Five-horsepower Floor Type Grinder

Fig. 2 shows a "Hisey" five-horsepower floor grinder which is provided with combination wheel guards as part of the standard equipment. These guards are of steel construction and the flanged outside cover adds greatly to the strength of the guard and prevents escape of dust. The grinder has an automatic starter operated by means of a quick-acting switch which permits the machine to be operated by an inexperienced workman, as throwing the current on or off is automatically controlled to insure protection of the motor. The starter and control switch are mounted in the base, but each is a separate unit and easily accessible. If desired, automatic speed regulation can be provided for the direct-current grinder.

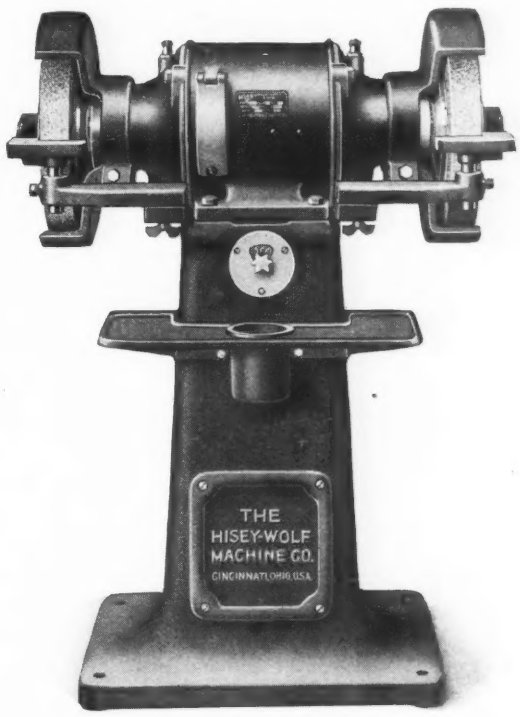
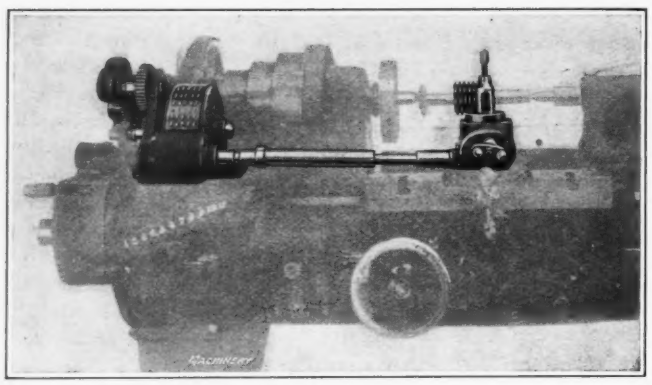


Fig. 3. Same Machine shown in Fig. 1 mounted on Column

These grinders are provided in two types for connection with alternating- and direct-current circuits. The direct-current machine is furnished with motors for connection with 115- to 230-volt current, while the alternating-current grinder is made in four styles, all of which are provided for connection with 220-volt current, 60-cycle, two- or three-phase, or 25-cycle, two- or three-phase. The direct-current grinders run at 1100 R. P. M., the 60-cycle alternating-current grinders run at 1140 R. P. M., and the 25-cycle alternating-current machines at 1450 R. P. M. The principal dimensions of all machines are as follows: diameter of spindle at wheel mounting, 1½ inch; distance between wheel centers, 43 inches; size of base, 23 by 40 inches; height from bottom of base to center of spindle, 35 inches; and net weight, 1550 pounds.

CARROLL & JAMIESON RELIEVING ATTACHMENT

The Carroll & Jamieson Machine Tool Co., 257 Davis St., Batavia, Ohio, is now making a relieving attachment for use on the Carroll & Jamieson 14-inch lathes. This attachment,

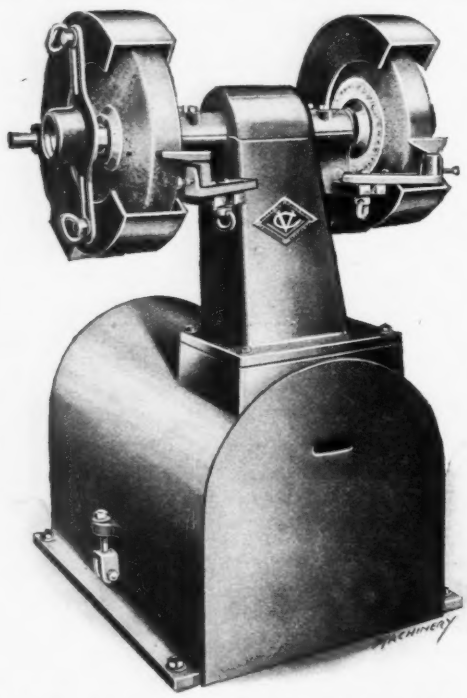


Carroll & Jamieson Relieving Attachment

which provides for indexing for 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14 and 16 teeth, may be used for relieving cutters, reamers and other tools with these numbers of teeth. The relieving attachment is mounted on top of the gear-box; it is secured in place by two screws and engages with a gear on the spindle. A special compound rest top and swivel is furnished with the attachment, which will fit any of the Carroll & Jamieson 14-inch lathes.

VALLEY CITY GRINDERS AND BUFFERS

In the motor-driven grinders and buffers which have recently been added to the line of machines built by the Valley City Machine Works, Grand Rapids, Mich., the most noticeable feature of design is that the motor is enclosed in the base. This gives all the advantages of the self-contained motor-driven machine with belt connection to the spindle, and the



Valley City Grinder with Driving Motor fully enclosed in Base

added advantage of thorough protection for the motor. The machines are built in two sizes, the larger of which is shown in the accompanying illustration, which is suitable for a grinder head carrying wheels up to 18 inches in diameter; and this machine is provided with a base having ample room to accommodate a five-horsepower motor. Bases are provided to carry different sizes of Valley City grinder heads according to the requirements of the work.

The motor is mounted on a pivoted base at right angles to the grinder spindle which is driven by a quarter-turn belt. Tension of this belt is regulated by means of an adjustment screw at the base of the machine. It is claimed that the motor-driven machine with belt connection to the spindle possesses an advantage over a machine with direct-connected motor drive in that all shocks are absorbed without danger of damaging the motor. In the present machine the manner in which the motor is encased also insures keeping it free from dirt and grease.

VALLEY CITY SEMI-UNIVERSAL MILLING ATTACHMENT

The Valley City Machine Works, Grand Rapids, Mich., is now building a semi-universal milling attachment for use in

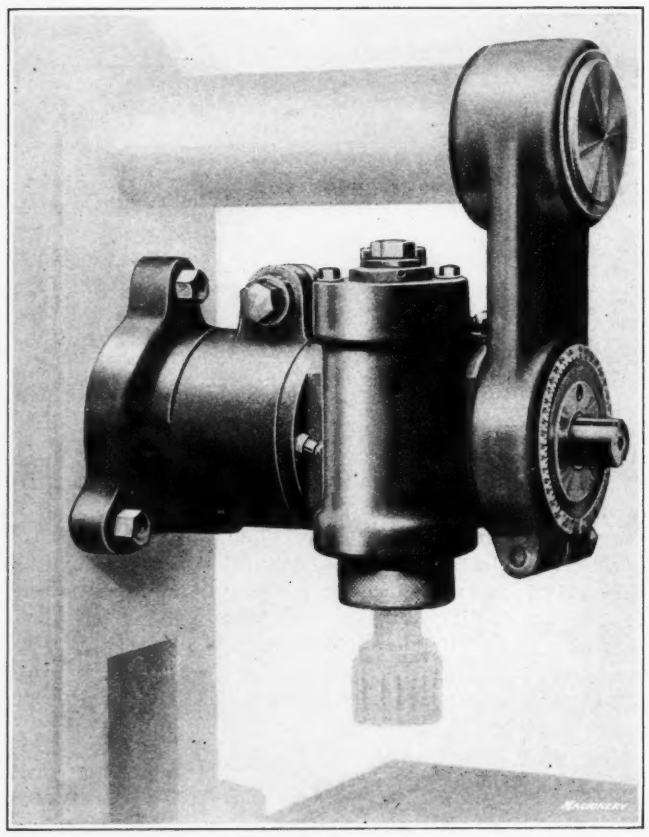


Fig. 1. Semi-universal Valley City Milling Attachment in Vertical Position

connection with the No. 1½ milling machines of its manufacture. This attachment enables the operator to get closer to angular cuts and still have a rigid support. Provision is made for swinging the attachment clear under the over-arm, and it may be reversed if necessary. The hole through the spindle is accessible when the spindle is in a vertical posi-

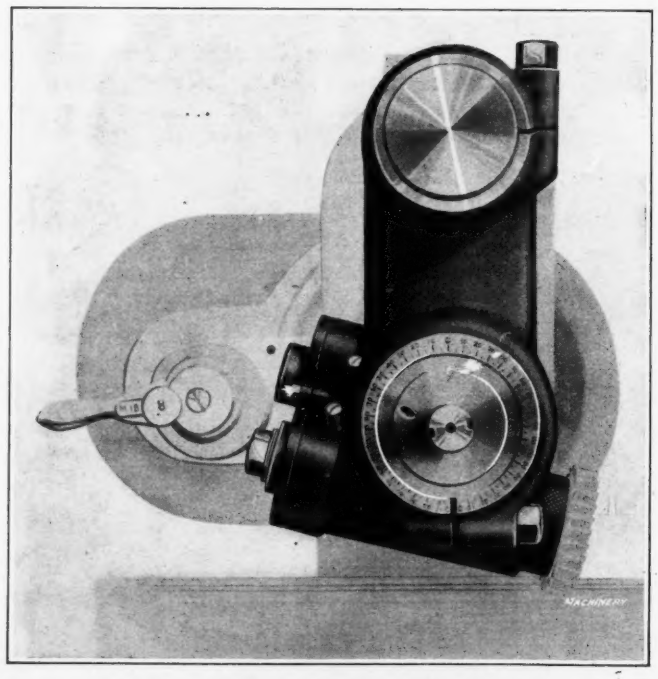


Fig. 2. Semi-universal Valley City Milling Attachment in Inclined Position

tion, as the spindle of the attachment is offset from the milling machine spindle. Power for driving the attachment is transmitted through a splined arbor, coarse-pitch miter gears, an intermediate ball bearing shaft and a pair of heavy steel spur gears. The spindle of the attachment rotates in the same direction as that of the milling machine and has a No. 10 taper. A clamp base is furnished with the attachment, which is bored to fit the spindle box and secured to the column with screws. This attachment may be applied to other makes of milling machines with slight modifications.

FOSTER GEARED-HEAD SCREW MACHINE

The Foster Machine Co., Elkhart, Ind., has recently developed an all-geared head for its No. 5 screw machine, which gives the advantage of instantly obtainable speed changes and high power, owing to the high belt speeds that can be

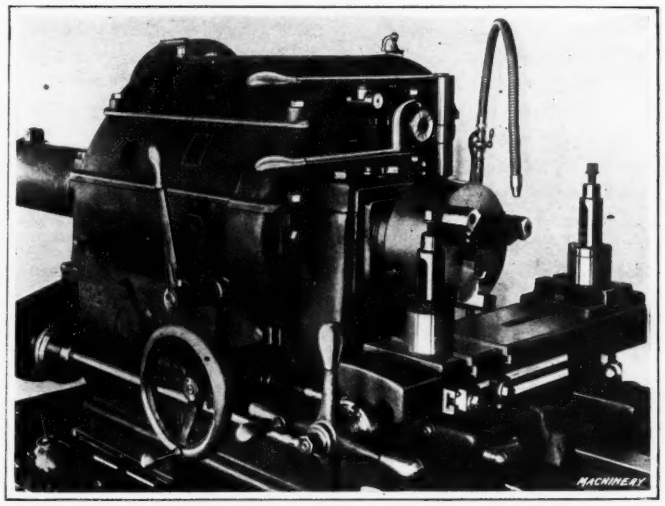


Fig. 1. All-geared Head for Foster No. 5 Screw Machine

employed. This geared head is a complete unit made to fit the standard Foster No. 5 screw machine; the cone pulley of the standard back-geared machine is replaced by a three-gear cluster mounted on a sleeve journaled to the spindle, and

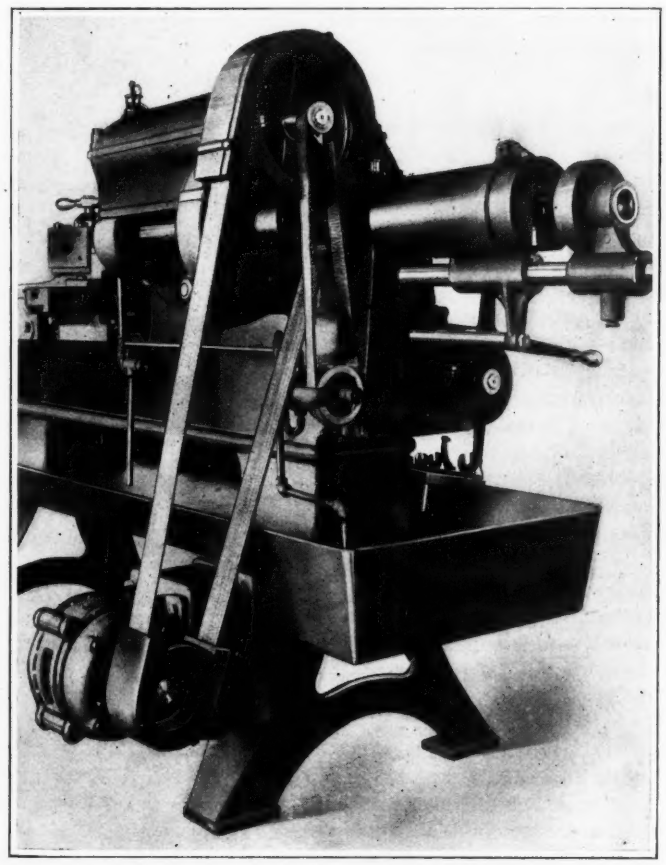


Fig. 2. Rear View of Geared-head Machine, showing Motor Drive

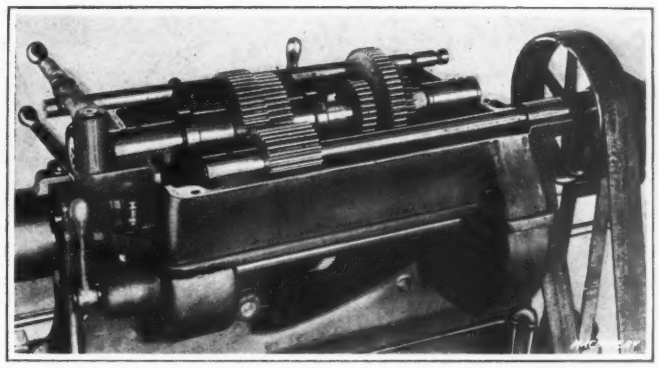


Fig. 3. Arrangement of Gearing in Head of Foster Screw Machine

this gear cluster is arranged to engage a triple sliding gear cluster mounted on a shaft located above the spindle. This shaft is journaled in bronze-bushed bearings carried by the main head casting, and the sliding gear cluster is operated by a rod and hand-lever.

On the same shaft with the gear cluster are two friction gears provided with a cone type of friction arranged to engage either gear. The purpose of this friction is to stop, start or reverse the machine, one of the gears being engaged by a reversing idler mounted beneath the main driving pinion, which is mounted on the pulley shaft that is also journaled in bronze-lined bearings held by the main head casting. All this gearing is illustrated in Fig. 3, which shows the cover removed from the head to show the construction. The reversing friction clutch is operated by the lower of two horizontal levers shown at the front of the head in Fig. 1. Attention is called to the three conveniently located speed-changing levers,

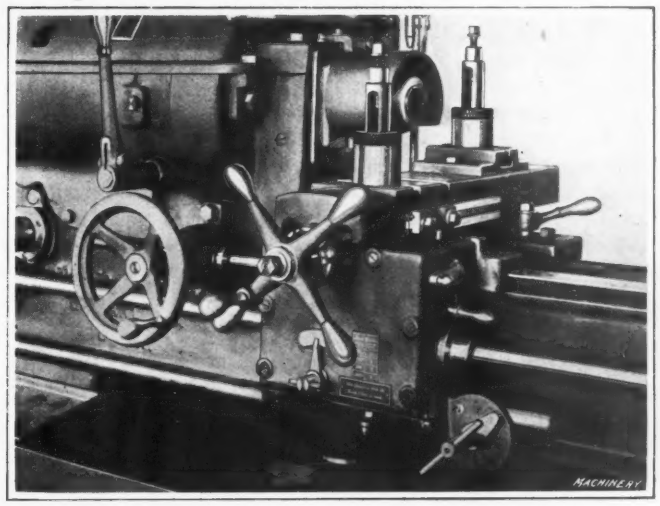


Fig. 4. Close View of Cross-slide on Foster Screw Machine

the vertical one of which—shown in Figs. 1 and 4—is for operating the friction clutch mounted on the spindle, the arrangement being the same as that used on the cone type of Foster screw machine.

A 2½-inch belt carried by a 10-inch pulley is employed for driving the geared-head machine; the pulley runs at 900 revolutions per minute, giving a belt speed of 2350 feet per minute, at which speed a single belt working under ordinary shop conditions has a capacity for delivering 6.2 horsepower. The reversing friction in the head is powerful enough to pull a still heavier load without damage, and the power rating just given is conservative, although greatly in excess of actual requirements of the machine, as a two-horsepower motor is employed for the general run of work. When work of an unusually heavy character is to be handled, it may be advisable to use a three-horsepower motor.

Fig. 2 shows a machine equipped with a two-horsepower General Electric motor mounted on the leg. The motor runs at 1800 revolutions per minute, and this high belt speed makes it possible to employ a high-speed motor of small size. The value of this feature will be appreciated by those experienced in the selection of motors for similar applications, as the cost

of the motor is relatively low and the amount of space occupied reduced to a minimum. Attention is called to the efficient method of guarding the belt at both the motor and machine pulleys. When so desired, the machine can be driven with equally satisfactory results through a plain tight and loose pulley countershaft.

Fig. 1 shows a machine equipped with a three-jaw geared scroll chuck which swings clear of the cut-off slide; and Fig. 4 shows the application of a collet type automatic chuck, the capacity of which on the Foster No. 5 screw machine is for work up to 1 13/16 inch in diameter. The scroll chuck is 7½ inches in diameter and the swing over the cut-off slide is 8¼ inches. The cut-off slide and carriage are plainly shown in Fig. 4; hand longitudinal and power cross feed are provided with four changes of feed. Six changes of speed are available in the geared head, which are in geometrical progression and cover a range of from 34 to 466 revolutions per minute. These changes and the proper lever movements to obtain them are indicated on a speed chart mounted on the head of the machine, as shown in Fig. 1.

OTT PLAIN GRINDING MACHINE

The Ott Grinder Co., 32 N. Clinton St., Chicago, Ill., is now manufacturing the No. 8 plain grinding machine shown in the accompanying illustrations, which has a capacity for handling work up to 5 inches in diameter by 12 inches long. The machine is equipped with automatic feed and provided with a wheel 10 inches in diameter by 1¼ inch face width. It is especially adapted for the manufacture of duplicate straight cylindrical or tapered parts, the dimensions of which are required to come within close limits.

The wheel spindle is made of alloy steel, hardened, ground and lapped; the bearings are lined with bronze, provided with means of adjustment and furnished with ample facilities for lubrication by means of large self-feeding oilers. The automatic cross-feed can be set to feed at either or both ends of the table traverse and is automatically thrown out when the work is ground to size. The table drive is through worm and worm-wheel which insures a smooth uniform travel. Automatic travel is controlled by quickly adjustable dogs, and the table handwheel is disconnected during the time that power table travel is employed. The swivel table turns on a large central stud which is hardened and ground, and clamps are provided at both ends for securing the table in the desired position. The headstock is arranged for both dead and live center drive through a single pulley, and slides on V and flat ways. The tailstock also slides on V and flat ways, and both headstock and tailstock are fastened by a hook bolt.

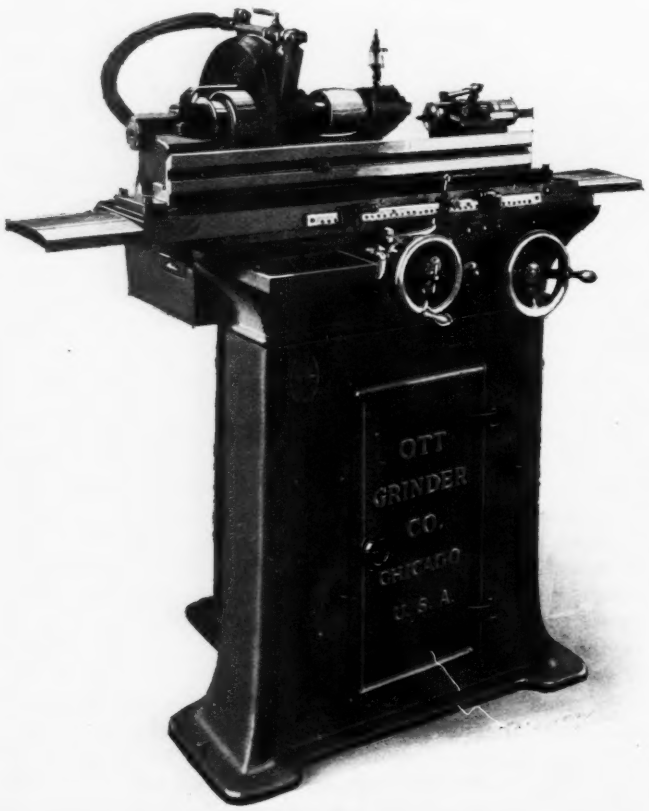


Fig. 1. Ott No. 8 Plain Grinding Machine

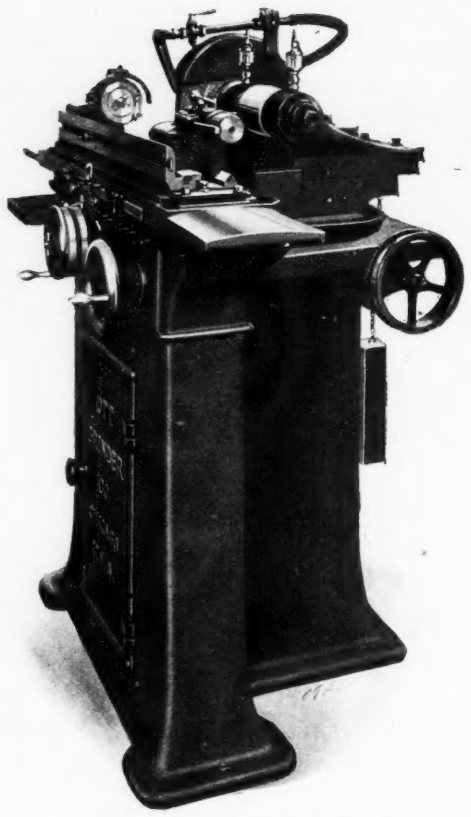


Fig. 2. End View of Ott No. 8 Plain Grinding Machine

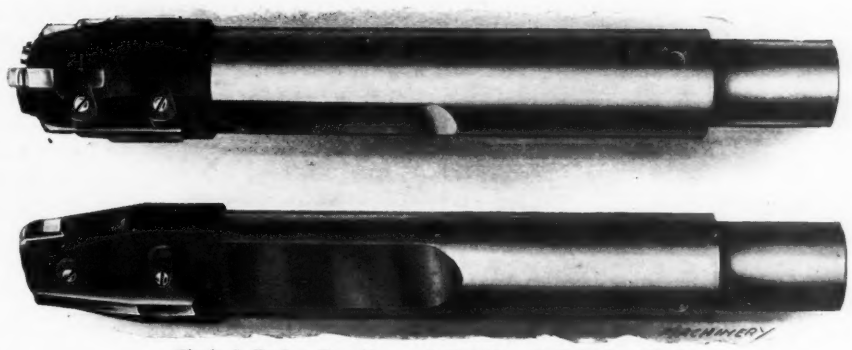
For use in the performance of wet grinding operations, ample facilities are provided for delivering a copious flow of water from a tank cast in the bed, which is provided with a settling pan that is easily removed for cleaning. The pump is of simple construction and requires no priming or packing. A universal back-rest for use on these machines has both vertical and horizontal movements, and is capable of delicate adjustment. Adjustable set collars are provided for maintaining the size of the work. Regular equipment furnished with the machine includes one 10- by 1¼-inch grinding wheel, one universal back-rest, one wheel truing device with a diamond, one center grinding attachment, one set of work dogs, overhead works, water guards, and the necessary wrenches for making all adjustments.

The principal dimensions of this machine are as follows: diameter of headstock and tailstock spindles, 1½ inch; diameter of work-carrying centers, 11/16 inch, No. 2 Morse taper; number of work speeds, four; range of work speeds, 130 to 390 revolutions per minute; size of front grinding wheel spindle bearing, 1⅝ inch diameter by 3¾ inches in length; size of rear grinding wheel spindle bearing, 1½ inch in diameter by 3½ inches in length; size of grinding wheel spindle pulley, 4 inches in diameter by 2½ inches face width; capacity of grinding wheel guard, for wheels up to 10 inches in diameter by 2 inches face width; number of grinding wheel speeds, two; available grinding wheel speeds, 2250 and 3200 revolutions per minute; number of table traverse speeds, four; range of table traverse speeds, 34 to 120 inches per minute; minimum automatic cross-feed, 0.0002 inch; maximum automatic cross-feed, 0.004 inch; size of countershaft tight and loose pulleys, 10 inches in diameter by 4 inches face width; speed of countershaft tight and loose pulleys, 375 revolutions per minute; power required to drive the machine, 3 horsepower; floor space occupied, 31 by 68 inches; swivel table graduated to angle of 15 degrees; capacity for taper grinding, up to 3 inches per foot; and net weight of machine, 1500 pounds.

BLACK & DECKER SHELL BORING HEAD

The Black & Decker Mfg. Co., Baltimore, Md., has recently developed and placed on the market a boring head especially designed to meet the requirements of shops engaged in the manufacture of shells. These heads are of the inserted-blade type, and are customarily furnished in pairs, one of which is

for the purpose of rough-boring the wall and bottom of a shell, while the other is employed for finishing the same surfaces. Each head has three blades, two of which are for working on the side wall, while the third is a nosing cutter for finishing the bottom. The side wall blades are set 180 degrees apart and the nosing blade is set half way between or at right angles to them. It will be seen from the accompanying illustration that the rear of the nosing blade overlaps the side blades, and in the case of the finishing head all blades are cylindrically ground in place to insure obtaining the proper contour, thus obviating leaving a shoulder in the shell at the junction of the bottom of the side wall.



Black & Decker Roughing and Finishing Shell Boring Heads

These heads are economical in their use of high-speed steel, as the design has been worked out in such a way that the blades employed are of the minimum cross-section that is required for machining the work for which these tools are intended; and the blades can be lined out and reground a number of times before discarding the small weight of steel contained in the stubs. This eliminates the large source of waste incident to the use of solid-blade boring heads when working to the close limits required in munition work. Each blade is thoroughly backed up and supported by the metal of the head, and an effective wedge and screw system of clamping makes it unlikely that a blade will loosen or chatter while in service. Provision is also made for the unobstructed flow of chips back from the blades, and for the flooding of blades with lubricant under pressure, that is carried through a central lead. All heads, clamps and screws are casehardened, and the shanks are accurately ground to fit the turret.

WINFIELD ELECTRIC RIVETER

The Winfield Electric Welding Machine Co., Warren, Ohio, is now building a type R-4 semi-automatic electric riveter, which is illustrated and described herewith. This machine is said to be noiseless in operation, operate rapidly and produce perfect work. It has a capacity for handling rivets up to ⅜ inch in diameter and is equipped with a 1½-horsepower Crocker-Wheeler motor, a 10-K.W. transformer, and a 50-ampere Cutler-Hammer remote control solenoid switch. The drive is through noiseless rawhide gears, and a six-step self-contained regulator provides for controlling the amount of current used.

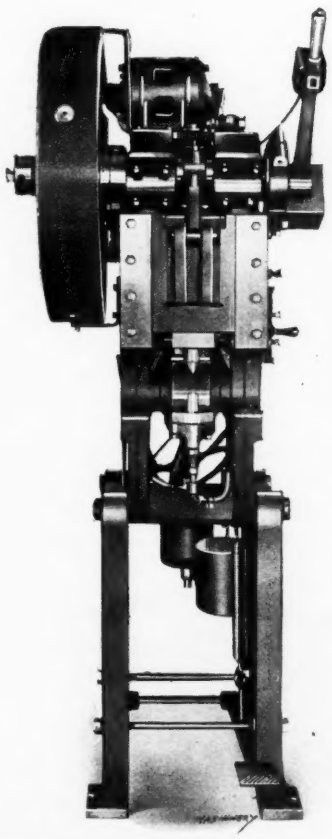


Fig. 1. Front View of Winfield Electric Riveter

In operating this machine, the work with the rivet in place ready to be headed is placed between riveting electrodes, with the rivet head resting in a depression in the lower electrode. The upper electrode is then brought into contact with the rivet by means of a hand-lever, and current is applied by operating a push-button located in the end of this lever. When the temperature of the rivet has been raised to the required degree, a foot-treadle is depressed, releasing the clutch and causing the slide to further depress the upper electrode, which results in upsetting and forming a head on the rivet. This machine is so designed that different gages of metal and variations in thickness of material are taken care of by a large rubber bumper; and the clutch is especially designed to make it impossible for the machine to operate more than once each time the foot-treadle is depressed. The floor space occupied by the riveter is 30 inches by 46 inches; the height of the machine is 90 inches; and it weighs approximately 1800 pounds.

MORRIS 22-INCH LATHE

The Morris Machine Tool Co., Cincinnati, Ohio, is now building a 22-inch engine lathe, the design of which is similar to that of the 16-inch lathe of this company's manufacture which was illustrated and described in the November, 1911, number of MACHINERY. The principal dimensions of the machine are as follows: swing over bed, 23⅛ inches; swing over carriage, 15½ inches; size of front spindle bearing, 3¾ inches in diameter by 6 inches in length; diameter of hole through spindle, 2 inches; diameter of cone pulley steps on double back-geared lathe, 11½, 12¾ and 14 inches by 4¼ inches face width; and weight of machine, approximately 4500 pounds. These lathes are built with single or double back-gears and with quick- or semi-quick-change feed-box.

WARE ISOMETRIC PICK-UP TRIANGLE

R. B. Ware, 101 Northampton Ave., Springfield, Mass., is now manufacturing the isometric pick-up triangle illustrated and described herewith. At the center of the triangle there is a convenient pick-up handle, which consists of a knuckle joint which is raised sufficiently above the surface of the triangle to enable it to be easily grasped between the thumb and finger. This knuckle joint fits in a slot cut in the triangle and pops up on either side through pressure applied by a music wire spring. If the handle is raised on one side of the triangle and this side is then put down on the drawing paper, the pick-up handle will immediately be pressed into the hole, after which the spring forces it up at the opposite side. Similarly, the triangle can be placed between the leaves of a book; or it can be packed up without occupying any

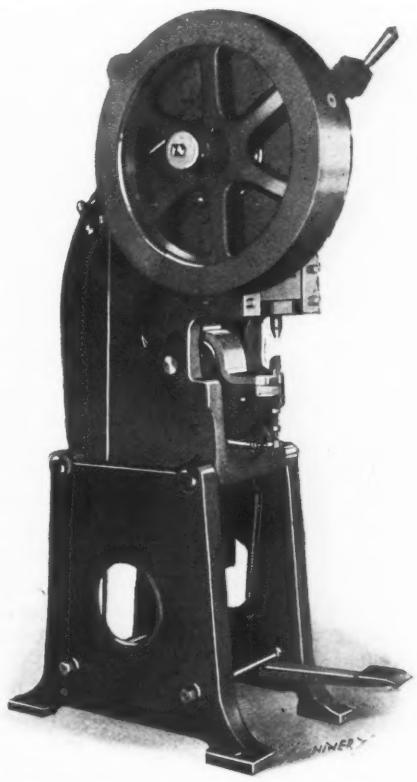
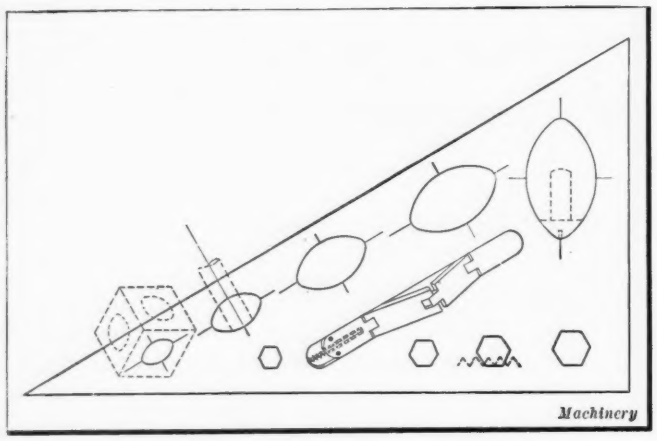


Fig. 2. Side View of Winfield Riveter shown in Fig. 1



Isometric Pick-up Triangle made by R. B. Ware

more space than an ordinary triangle, because in such a case the pick-up handle is held in the slot. This handle saves a lot of time in picking up the triangle.

By skillful manipulation this triangle can be used for cross-sectioning drawings, although it is not especially recommended for this work. For cross-sectioning, the hypotenuse of the triangle is placed against the T-square or other guide and pressure is applied on the two small brass retaining pins by one finger. After drawing a line, the knuckle joint is pushed down flat, while pressure is still applied on the retaining pins, thus causing the triangle to move into position for drawing the next line. The spaces obtained in this way will be about 1/16 inch apart on the long side of the triangle, and about 1/8 inch apart on the short side.

In addition to the pick-up device, it will be seen that the triangle is furnished with a number of elliptical shaped holes which are of isometric proportion and far more convenient to use than marking around the outside of templets. The long axes of these holes are parallel to the hypotenuse of the triangle, and lie in the correct angle for isometric drawing. All holes are beveled on both sides, so that the size drawn from them can be varied by tipping the pencil in or out; this beveling of the sides of the holes also avoids blotting if a ruling pen is used. The holes are convenient for rounding the ends of shafts, in which the short diameter is placed on the center line and the desired outline easily drawn. In addition, hexagonal shaped holes are provided for drawing in the head of bolts and the outline of nuts in plan view.

BROWN RECORDING THERMOMETER

A recording thermometer suitable for measuring temperatures up to 800 degrees F. or 425 degrees C. is one of the latest additions to the line of instruments manufactured by the Brown Instrument Co., Philadelphia, Pa. Its operation is governed by the expansion of gas with change of temperature, and in order to apply this principle a bulb of copper containing nitrogen gas under pressure is connected with a recording instrument by a small copper tube protected by flexible steel tubing. The recording instrument has a helical spring somewhat similar to that used in pressure gages, and the expansion of gas in the bulb exerts pressure which is conveyed by the connecting tube to this helix, causing an expansion according to the magnitude of pressure exerted. The helix is direct-connected to a recording arm which marks a record on the chart.

This type of instrument can be furnished with tubing as long as 100 feet if required, so that the recording gage can be placed at this distance from the point where temperature is to be measured, thus permitting application of the thermometer in numerous processes where it is desirable to keep a constant record of temperature on a chart. Some features of this thermometer are as follows: A Seth Thomas clock which revolves the chart is mounted directly on the front plate which supports the chart, thus assuring alignment of the clock and chart plate. Clips that hold the chart in position are mounted on the door so that when this door is swung aside the clips are swung away from the chart, permitting its easy replacement without interference. A device is furnished which automatically raises the chart pen from the chart when the door is opened and also automatically lowers it into position when this door is closed. A similar instrument is made in the indicating type where it is desired to indicate temperature on a dial instead of recording it on a chart. These thermometers are furnished with a number of different types of bulbs, with either threaded connection for insertion in mains and pipes, or with lead coating to withstand the action of certain chemicals and acids.

CLARK TRANSFER TRUCK

One of the latest additions to the line of elevating trucks manufactured by the George P. Clark Co., Windsor Locks, Conn., for use in transporting material around industrial plants, is the type WN truck which has a capacity for loads up to 2500 pounds. This truck is constructed entirely of metal, the frame, axles, rods and handle being made of steel, while the wheels are made of cast iron and provided with roller bearings. The handle is attached to a swivel designed in such a way that sharp corners can be easily turned. These trucks are made in ten different styles; six trucks have capacities for loads up to 1000 pounds and are made in various dimensions, making them suitable for use in connection with loading platforms, the maximum size of which covers a range from 32 by 32 to 42 by 32 inches in size. The four remaining styles of this type of truck have capacities for handling loads up to 2500 pounds in weight and are suitable for use in connection with loading platforms, the maximum size of which covers a range from 32 by 32 to 52 by 38 inches in size.

Fig. 1. Clark Industrial Truck with Platform lowered

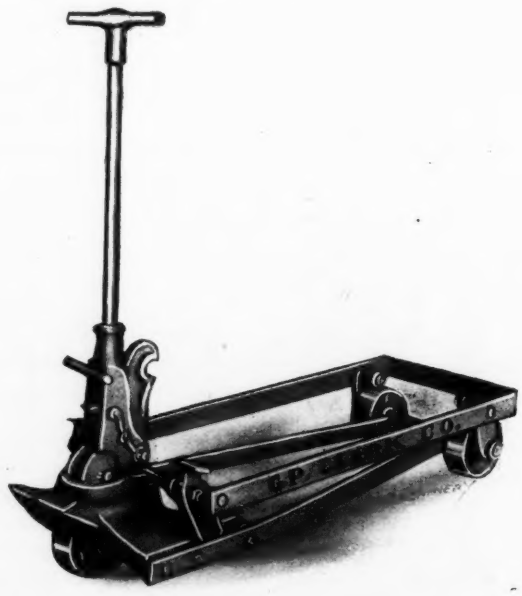


Fig. 2. Clark Industrial Truck with Platform elevated

BOYER PEDESTAL RIVETER

The Boyer pedestal riveter shown in the accompanying illustration is a recent product of the Chicago Pneumatic Tool Co., 1060 Fisher Bldg., Chicago, Ill., and is designed for use in riveting small parts that can be conveniently handled on a stationary machine. The design has been worked out in such a manner that the machine is operated by a foot-lever, leaving both of the operator's hands free to handle the work. The yoke consists of a crucible steel frame mounted in the end of a pipe column, all of which is supported on a cast-iron

Boyer Pedestal Riveter built by Chicago Pneumatic Tool Co.

base which has anchor bolt holes to provide for fastening it securely to the floor. The standard yoke has a gap of 8 inches and a reach of 11 inches, but special yokes may be furnished of any required dimension for handling larger work.

Where it is desirable to handle more than one size of rivet, a special dolly may be supplied, that will accommodate four different sizes of rivets. This dolly is so designed that it may be used in very close corners. The riveter head is a standard Boyer riveter 1 1/16 by 3, 1 1/16 by 4, or 1 1/16 by 5 inches, and is held in a clamp which permits of its being adjusted to compensate for wear on the dies or variation in length of rivets. The net weight of the machine equipped with a 1 1/16-by 3-inch riveter is approximately 173 pounds.

CORRECTION

An error appeared in the description of the Metalwood presses made by the Metalwood Mfg. Co. of Detroit, Mich., in the September number. The function of the knockout press shown in Fig. 2 is knocking or pushing the plug out of the bottom of British shells after the band has been set. The plugs are inserted to prevent the shells being distorted in the banding operation.

NEW MACHINERY AND TOOLS NOTES

Plug Wrench: Holden-Morgan Co., Ltd., Toronto, Ontario, Canada. A wrench especially designed for screwing in the base plugs of shells, although it could be used for other classes of work. The shell is held in a clamp and the plug is driven in by a mechanically operated wrench.

Jointer and Planer: Globe Inventing Co., 4877 N. Hermitage Ave., Chicago, Ill. A combination bench planer and jointer in which the thickness gage over the table can be set at any required height up to 4 inches, or it can be set to plane work on any angle up to 15 degrees. The table can be lifted and swung back for convenience when adjustment of the knives has to be made.

Rail Punching Machine: Covington Machine Co., Covington, Va. A machine developed for use in punching the bolt holes in the ends of two light rails at the same time. It is intended for use where the material handled does not weigh more than forty pounds per yard, this type of rail being used principally for industrial and mine railroads, and for the third rail of electrified lines.

Balancing Washer: Munning-Loeb Co., Matawan, N. J. A slotted washer intended for use in quickly bringing polishing wheels into balance. The washer is placed in such a way that the heavy end counterbalances the weight of the wheel which is off center, thus making it unnecessary to resort to the practice of tacking pieces of lead to the sides of wheels or driving in pieces of metal or nails.

Portable Electric Drill: Electro Magnetic Tool Co., Chicago, Ill. A machine in which the gears are made of steel, case-hardened and heat-treated to provide the required strength and durability. These gears run on bronze shafts immersed in grease in a separate gear case; and the thrust is carried by a ball thrust bearing. The motor is air cooled by a ventilating fan on the spindle, and the spindle and chuck are offset so that the tool will reach into close corners.

Weight Slide-rule: Hornyak & Kelly, 5526 Walton Ave., Philadelphia, Pa. This device was especially designed to meet the requirements of estimators in figuring the weights of machine shop materials. The dimension scales are graduated in inches and fractions thereof, and the weight scales in pounds and tenths of pounds. The weights of regular and irregular shaped pieces made of various metals and other commonly used materials are rapidly and accurately obtained by the aid of this instrument.

Planer Belt Shifter: Cincinnati Planer Co., Cincinnati, Ohio. This is an improved form of the planer belt shifting mechanism previously used by the Cincinnati Planer Co.; the shifting cam is entirely enclosed by a cover bolted to the overhanging arm, which eliminates trouble from belt scrapings, grit and dirt usually found on top of the planer shifting mechanism. The upper belt guide is provided with a sliding bearing on the over-arm bracket, which relieves the fulcrum stud from the downward pressure of the belt.

Roller Bearing: Delvante W. Crossland, 1608 Claus Spreckels Bldg., San Francisco, Cal. A roller bearing in which there is no sliding friction; the load bearing rollers are made of parallel solid hardened steel, so that the bearing can be heavily loaded without fear of failure. The bearing is provided with separating rollers that contact with the main rollers in such a way that no roller in the bearing can revolve without every other roller revolving. The separating rollers space the main rollers equally upon the journal, but do not contact with it.

Boring Tool: Clark Machinery Co., 1302 Ontario St., Cleveland, Ohio. The features of this tool are simplicity of construction and the ease with which it may be adjusted to the exact size and position required. Adjustment is made by worm and worm-wheel actuated by a wrench which makes it unnecessary to tighten the tool after adjustment and eliminates the necessity of loosening and tightening screws in making adjustment. The tool is made in five sizes, and all parts subject to wear are hardened to give them the required durability.

Sandblast Nozzle: W. F. Stodder, 218 S. Geddes St., Syracuse, N. Y. A sandblast nozzle operating on the injector principle and designed primarily for cleaning castings or other parts in a foundry or similar shop. This sandblast may also be used for removing scale from boiler tubes and boilers, and for removing rust and paint from structural steel, iron bridges, etc. In this nozzle the sand travels slowly through the hose, so that there is little wear; and an advantage claimed for the nozzle is that there is no sand tank which has to be filled.

Combination Disk Grinder and Saw Table: Globe Inventing Co., 4877 N. Hermitage Ave., Chicago, Ill. The arbor of this machine is so arranged that it is adapted for carrying either an abrasive wheel covered with abrasive cloth or paper, or a circular saw. Provision is made for mounting thin abrasive wheels on the arbor so that high-speed and hardened steel can be ground. The table tilts to any angle or can be raised or lowered at the back; it is provided with two adjustable angle rests that can be locked in any position by thumb-screws.

Munitions Parts Assembling Machines: Berggren & Pearson Machine Co., New York City. A battery of machines designed for assembling the bursting box for the contact detonator of 3-inch Russian shells. The battery consists of six machines so arranged that the two opposite machines assemble the same part of the work and are driven by the same belt. All the machines are mounted on a table 12 feet long by 30 inches wide, leaving ample room between the operators for loading and unloading the trucks which are rolled up to the assembling table.

Extensible Coupling for Mill Drives: Cutler-Hammer Clutch Co., Milwaukee, Wis. An extensible coupling for use in connection with herringbone gear drives on rolling mills, designed to eliminate trouble resulting from end thrusts or any constraint which does not leave the gears perfectly free to align themselves properly. The use of this coupling between the driving motor and herringbone pinion provides for transmitting the necessary power, leaving the pinion free to align itself with the gear, and unaffected by any end thrust caused by lateral motion of the shaft.

Rail Breaking Machine: Covington Machine Co., Covington, Va. A machine for breaking rails, the weight of which does not exceed 100 pounds per yard of length. This machine is of the open-throat type and was designed as a substitute for the closed machine similar to a guillotine shearing machine. It breaks the rail with a single stroke of the plunger, and as the shock is somewhat severe, special attention was paid to the design of the main bearing for the eccentric shaft. A cast steel block is used to support the bearing which is relied upon to save the main frame from unnecessary wear.

Welding Outfit: Thermalene Co., Chicago Heights, Ill. A new method of torch welding in which oxygen and a gas known as "thermalene" are employed. This gas was discovered by Karl Frederich Linus Wolf of Zurich, Switzerland, and is handled in this country by the Thermalene Co. It is claimed that this gas possesses a low inflammability and that danger from its explosion is almost negligible. The Thermalene Co. manufactures a portable outfit consisting of thermalene generator and the other equipment, mounted on a truck so that it may be conveniently moved from one place in the shop to another.

Internal Thread Millers: Holden-Morgan Co., Ltd., Toronto, Ontario, Canada. An internal thread milling machine designed for threading the nose or base of shell bodies. The shell is held in a hollow spindle which is driven by means of a bronze worm-wheel. At the rear of the spindle there is a ring which operates the trip trigger, automatically disengaging the drive after the work has been completed by one revolution of the spindle. Two types of these machines are built, which are known as the heavy and light styles. The light style has a leg base construction, but in other respects the design of both machines is the same.

Engine Lathe: Oliver Machinery Co., Coldbrook and Clancy Sts., Grand Rapids, Mich. A heavy-duty 26-inch engine lathe on which the headstock is heavily ribbed and provided with a long bearing on the bed. The front spindle bearing is 6½ by 10 inches in size and the rear bearing 4½ by 7 inches. The headstock is of the single-pulley geared type and there are two changes of speed provided from the countershaft, giving a total range of twelve speeds from 8 to 300 revolutions per minute. There are thirty-two changes of feed ranging from 0.013 to 0.333 inch per revolution; and thirty-two changes of threads ranging from 1 to 24 threads per inch.

Surface Grinder and Sander: Globe Inventing Co., 4877 N. Hermitage Ave., Chicago, Ill. A bench machine designed for use in finishing up any size of surfaces and shapes on wood, metal and other material. Any required abrasive cloth can be quickly attached to the roller by loosening three screws, and two kinds of abrasive cloth can be put on the roller at the same time, each covering half of the roller. The guide can be quickly set to the required height over the abrasive, and it can be set at any angle up to 15 degrees. The table can also be lowered or raised at either side, and it can be lifted and swung up to the back while replacing worn out abrasive cloth.

Shell Plug and Socket Millers: Holden-Morgan Co., Ltd., Toronto, Ontario, Canada. One machine was designed primarily for the performance of operations on shell plugs, although it could be adapted for external threading on other classes of work. On this base-plug miller the piece is chucked by means of a device which may be adapted for handling different types of work, and the thread is completely milled at one revolution of the work-spindle. Opening and closing of the chuck are controlled by a handle conveniently placed at the side of the machine. The socket miller is adapted for milling outside threads on fuse sockets, nose pieces, and fuse bodies; and this machine is provided with a chucking device especially adapted for holding these parts.

Horizontal Tapping Machine: H. E. Harris Engineering Co., 1041-1055 Broad St., Bridgeport, Conn. A horizontal tapping machine on which the forward and reverse drives are accomplished by a friction cone consisting of leather contacting with cast iron. The leather forms a cushion to give an easy and sensitive though powerful grip under slight pressure. The forward friction is thrown into action by a slight pressure on the end of the tap applied by pushing up the hole in the work against it. When the work has been tapped to the required depth and the spindle in the tailstock comes into contact with a stop, the cone friction is automatically released by the action of the tap drawing into the work; and the rotation is then reversed to back out the tap by drawing the work away from the tap.

GEAR TESTING MACHINE

The machine here illustrated and described is the outgrowth or evolution of a previous machine, designed and built by Wilfred Lewis for the use of the American Society of Mechanical Engineers' committee on standards for involute gears. This was referred to in a paper presented at the American Society of Mechanical Engineers' joint meeting with the Institution of Mechanical Engineers at Birmingham in 1910, and a later design was presented again to the American Society of Mechanical Engineers in June, 1914.

Prof. Charles R. Richards, in charge of the Department of Mechanical Engineering of the University of Illinois, be-

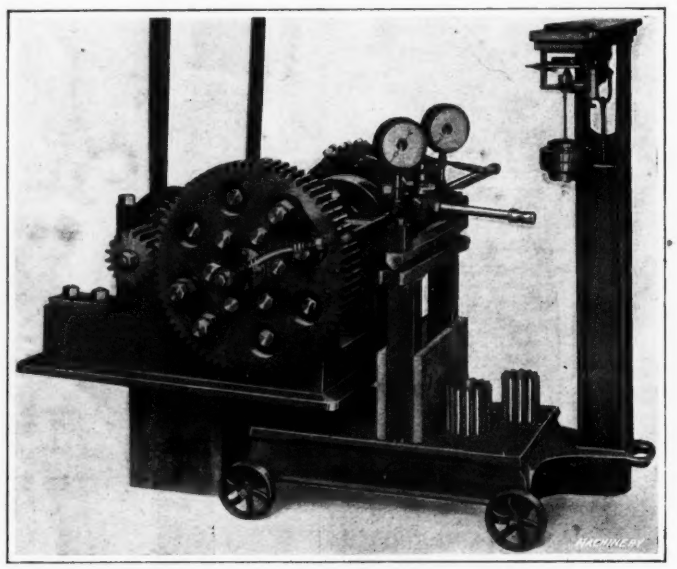


Fig. 1. Improved Gear Testing Machine built for University of Illinois

came interested in the problems which the latter machine was designed to solve, and ordered one for his mechanical laboratory. Before work was begun upon it, however, he noticed that no means had been provided to measure the power consumed, and, to make the machine more comprehensive in its scope, Wilfred Lewis agreed to add this feature, which had been one of the chief considerations in the first machine. The present machine has, therefore, been made to combine the means for controlling and measuring the pressure on gear teeth in action, with a later construction designed to measure the power consumed.

The former machine, which was described in the American Society of Mechanical Engineers' *Transactions* for 1914,* had a cast-iron frame or base, designed to rest upon a solid foundation. This construction has been taken bodily and mounted upon two horizontal axes, one of which coincides with the axis of the driving shaft while the other is a knife-edge resting upon portable platform scales, as shown in Figs. 1 and 2. A stand has been introduced to encircle the driving shaft and carry a foot down through an opening in the main frame of the machine. This foot rests upon a block of stone or concrete represented in the illustrations by a wooden box, and it will be understood that the shaft bearings are carried in this stand on ball bearings. On the other side of the machine, caps for the main bearings have been extended to carry the knife-edge as shown. The weight of the whole machine is therefore divided between these two supports at a certain distance apart, depending upon the size of the pinions used.

When driven in one direction, the load on the scales is increased, and when driven in the other direction it is decreased by the driving torque, as measured by the arm of the couple between supports. Fluid pressure is admitted to either side of the load-piston through a three-way cock, as shown, and the pressure resulting on the gear teeth is shown by the gages. It will be seen that this pressure can be readily reversed while the gears are running, and with a suitable countershaft or motor attached to the driving shaft

* This paper was published in the September, 1914, number of MACHINERY.

the direction of motion can also be reversed. With eighty pounds' fluid pressure in the load cylinder, the working load on the gear teeth becomes about 5000 pounds, and this is expected to break test gear teeth in cast iron, four per inch and 1 inch face or thereabouts at some speed to be determined.

The effects of various lubricants on the friction load can also be studied and the effects of wear at different speeds and loads. When breaking loads are approached, the test gear can readily be enclosed by a frame attached to a flange around the main casting so that broken teeth will not be thrown off to endanger the operator. No danger of a general smash-up is to be expected, however, because the remaining teeth will continue to mesh properly no matter how many may be broken. Of course the improvised foundation and the supporting stand on scales, as shown in the illustrations, will be replaced by substantial substitutes when the machine is placed in service.

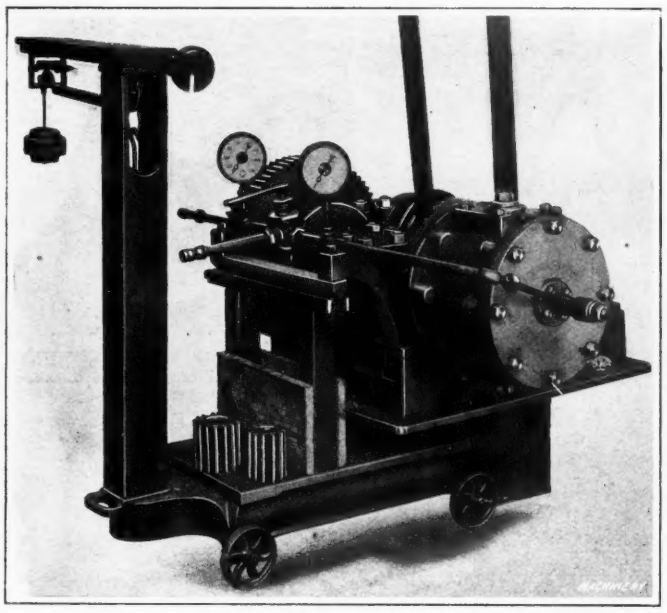


Fig. 2. Opposite Side of Gear Testing Machine shown in Fig. 1

* * *

MACHINING OPERATIONS ON RUSSIAN MILITARY RIFLE STOCK*

Several large plants in this country are at present engaged in the manufacture of the Russian military rifle stock; the equipment for this work varies to some extent in the different shops. One plant has an equipment which has been laid out along original lines with results that have been found highly satisfactory. The average time required with standard equipment to turn out the Russian military rifle stock is 1¼ man-hour, and in the plant referred to it is 9/10 man-hour per stock, with a total daily production based on 6500 stocks and operating on two shifts.

Many of the machines used for this work are novel in their application to the production of military rifle stocks. One of the interesting machines used is that for bandsawing the outline. The stock is held in a fixture which locates it from the top and front end, and when it is clamped, the stop at the front end automatically drops away. This fixture is held on a table which moves forward while the front end of the stock is cut off to length and the butt end milled to the required outline. The table is then returned to another stop and a special profiling cutter is brought into operation to profile the outline for the butt plate on the top and rear end. A lever is then operated, bringing into play a tool that hollow-mills the diameter at the front end and drills one hole in the butt to act as a driving point while turning. This machine is made by McKnight & Sons, Fitchburg, Mass., and produces fifty stocks per hour.

In rough- and finish-turning the fore end, a radical departure is made from the old practice of performing this operation in the stock turning lathe. In this case, the work is done in a fore-end stock turning machine built by Olney & Warrin, in which the stock is located by the ends and top, and the work is brought up to a set of cutters of the proper form and of a length sufficient to turn the entire fore end at one setting. The rough and finish cuts are taken at one setting by having the work make two revolutions, feeding in to the second stop for the second cut. The production is three stocks per minute.

In turning the butt end, use is made of a stock turning machine of the Blanchard type, but instead of using one tool with a number of cutters inserted in the periphery, two tools are used, each of which cuts one-half the length to be turned; these tools are a special form of saw which is very easily kept in shape, and is greatly superior to the old type of turning tool. The production is twelve stocks per hour.

For inletting, it is the practice to perform the various cuts separately, limiting the number of cutters in each operation and utilizing more machines so as to reduce the operation to the simplest form possible and obtain a greater output from each machine. The machines are much less complicated and cost considerably less than those equipped with six, eight or ten cutter-spindles.

In the Russian stock there is a mortised opening ⅜ inch by 2¼ inches, and the regular practice is to make this opening on an inletting machine. For this work a special machine has been built by the New Britain Machine Co., similar to that used for mortising wood level blocks, made by the Stanley Rule & Level Co. This machine has a table fixture on which the stock is placed, and it is provided with a feed mechanism that operates in a vertical plane. The head of the machine is arranged to carry a chain cutter; this cutter comprises a chain with links, the outer faces of which are formed with cutting edges and which is arranged to be driven by a sprocket and pass over a guide bar that gives it the proper tension and position. The production of this machine is four stocks per minute.

D. T. H.

* For methods of manufacture and equipment used in the production of military rifles, see "The Military Rifle," published in the April, May and June numbers of MACHINERY.

* * *

FIFTH ANNUAL CONGRESS OF NATIONAL SAFETY COUNCIL

The fifth annual congress of the National Safety Council, an employers' organization formed for the purpose of establishing a clearing house of information on accident prevention, sanitation, health conservation, etc., will be held in Detroit, October 17, 18, 19 and 20. The importance of conserving the human element is voiced by a prominent manufacturer who recently said:

> I believe we are fast approaching the time when it will be no longer possible to make any such revolutionary economies in industry as were brought about by the invention of the steam engine, the application of electricity and the development of steel making. I believe the next great field of economy lies along the line of conserving the human equipment of our plants.

Chemical section, foundry section, iron and steel section, mining section, public utility section, steam railroad section and health service section meetings will be held, at which papers on various matters concerning the prevention of accidents, promotion of health and sanitation, etc., will be presented by experts in the various lines represented. It is expected that about 140 speakers will take part.

* * *

MONUMENT TO JOHN ERICSSON

On August 31 President Wilson signed a bill introduced in Congress for the erection of a monument to Capt. John Ericsson, the well-known engineer who designed the *Monitor*, which, during the Civil War, turned the naval power in favor of the North. The monument will be erected at Washington, D. C. A number of members of the American Society of Mechanical Engineers were active in securing the passage of the bill, because they considered the nation ought to erect a monument commemorating this great engineer. It is the first time that Congress has made an appropriation for the erection of a monument to any citizen who has not held high political office, and the first time that a monument has been erected to an engineer at public expense.

B. & S. Plain Grinding Machines

Smooth, efficient operation that counts on your production records

Built for Heavy Manufacturing Grinding

No. 12 Capacity to 8" diameter, 36" long.
No. 14 Capacity to 10" diameter, 48" long.
No. 16 Capacity to 10" diameter, 72" long.

Also two smaller sizes in plain machines and a full line of Universal, Tool, Cutter and Surface Grinders.

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Orders and inquiries addressed to this new office will receive prompt attention.

You can get with these machines the steady production that is necessary to keep your grinding output balanced with the rest of your shop in these busy days.

Week after week, and month after month, they will produce consistently and at the fastest practical rates work that will come up to your most exacting standards for accuracy and finish.

There are good reasons for this ability. Here are a few:

Rugged support of working parts. The stability required in machines for heavy manufacturing is there. An examination of the bed, wheel stand, and other parts will reveal ample thickness of metal and strong bracing at points of greatest stress. But careful calculations have eliminated unnecessary weight that would tend to make the machines clumsy and slow to operate.

Bearings carefully aligned. Having bearings properly supported, correctly designed as to size, and then accurately aligned is responsible for the reliability of these machines in long continued service.

Just the right combination of speeds and feeds is always at your disposal—no excuse for using a combination that will not give the very fastest production consistent with the finish required.

You should know more about these and other features such as the Automatic Cross Feed, Universal Back Rests, etc. Write us for a descriptive circular of the machine best suited to your work. (See list of capacities above at left.)

Brown & Sharpe Mfg. Company,

OFFICES: 20 Vesey St., New York, N. Y.; 654 The Bourse, Philadelphia, Pa.; 626-630 Washington Blvd., Chicago, Ill.; 305 Chamber of Commerce Bldg., Rochester, N. Y.; Room 419, University Block, Syracuse, N. Y.; Room 2538, Henry W. Oliver Bldg., Pittsburgh, Pa.
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B. & S. Standard Gauges

Work does not go to the scrap pile if it conforms to these gauges

Every day you are making standard sizes in your grinding department. How do you measure this work to insure against too high a percentage of spoilage from wrong setting up of machines?

It is a costly error that is discovered by an inspector after hundreds of pieces have been ground. Figured in dollars and cents it represents not only the actual cost of the work spoiled but the cost of a delay in production that retards deliveries and makes dissatisfied customers.

A set of Brown & Sharpe Standard Gauges or a box of Standard Reference Discs in your shop tool rooms will help wonderfully in maintaining correct sizes.

Both discs and gauges are made from the best tool steel, hardened, ground and lapped to exact size, with large measuring surfaces to prevent wear. They are furnished singly or in sets.

A copy of our No. 27 Catalog should be in your reference file. It describes our full line of standard and limit gauges and other useful tools for shop tool rooms.

Providence, Rhode Island, U.S.A.

CANADIAN AGENTS: The Canadian Fairbanks-Morse Co., Ltd., Montreal, Toronto, Winnipeg, Calgary, Vancouver, St. John, Saskatoon.

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LAWS OF FOREIGN COUNTRIES RELATING TO BUSINESS*

UNFAIR COMPETITION AND TRUST LAWS OF VARIOUS COUNTRIES AND INTERNATIONAL AGREEMENTS AFFECTING THEM

IN most countries, the laws governing the formation of monopolies and unfair competition are based on the laws of France. These laws are chiefly found in the general codes which were enacted shortly after the French Revolution. The principal provision of the penal code makes it possible to punish by imprisonment and fine anyone who shall effect the advance or decrease of price of any merchandise or public securities (above or below the prices that natural and free competition would have fixed) by the circulation of false reports, by offers of higher prices, or by agreement not to sell or to sell only at a certain price. Court decisions show that the circumstances of each case affect its standing. The court decided that it was illegal for all the important iodine manufacturers to combine: to divide the field that supplied the raw material; to fix the quantities to be purchased in each field and the prices to be paid therefor; or to sell their entire output through a syndicate that would fix the price and other conditions of sale. But when those producing about two-thirds of the phosphate of the Somme region combined to sell their products, fix the prices, etc., the court decided that the combination was legal because it did not include more than two-thirds of the production and there was competition from other parts of France and from Belgium.

The Belgian as well as the French criminal codes provide that:

> Every person, who with the purpose of compelling the increase or decrease of wages, or of interfering with the free operation of industry or of labor, shall have committed violence, proffered insults or threats, adjudged fines, prohibitions, interdictions, or any proscription whatever, either against those who labor or against those who employ labor, shall be punished with imprisonment, etc.

The combinations of employers and of laborers for the purpose of fixing the price and the conditions of labor are legal, though subject to restriction. In one instance a court said:

> Although employers and laborers have the right to combine in order to fix the price, the conditions of labor, etc., the use of this right is limited and the abuse of it is repressed by the laws which protect the laborer and his work. It is permitted to trade unionists to make by-laws which govern the members of the union and which authorize the expulsion of a member who disobeys them, but in advising third parties of this expulsion with the threat that they will be exposed to disagreeable consequences in case they take the excluded person into their service, the secretary of the union attacked the freedom of the latter; and he ought to compensate the damage caused by that illicit act.

When a Belgian association of dealers in druggists' supplies tried to "quarantine" a dealer for non-observance of the regulations of the association, although he was not a member and had no agreement with it, the court held that the defendant was not permitted to "resort to practices to induce all or a certain number of manufacturers to refuse to sell to the plaintiff or to sell only at a price that made it impossible to resell at a profit." While the court held that there was ground for an action of damages, it referred the case to an accountant to determine what damages may have been sustained by the plaintiff.

The civil code of Austria says that unpermitted companies have no rights either against their members or against others and that they are incapable of acquiring such rights. The code then defines these as follows: "Unpermitted companies are those which are forbidden by the political laws or which are clearly repugnant to security, public order, or good morals." The highest court in Hungary, however, declared the combination legal when several contractors agreed to regulate their participation in bidding on public contracts, including provisions as to prices and conditions and penalties for breach of that agreement. The court said:

> If those engaged in a branch of business combine to hinder the offer of cut prices which endanger the economical operation of the industry in order thereby to maintain a reasonable price for their work, an agreement pursuing such an end, and not fixed for too long a period (it was five years in this case), can be regarded as inconsistent neither with the interest of the participants nor with that of the public nor as repugnant to good morals. * * * A combination which seeks to avoid a crisis injurious both to the contractor and to the party employing him serves also the interest of the public.

The Italian civil code contains the following provision: "Whatever act of a person causes damage to another obliges him by the fault of whom it happens to compensate the damage." But the courts have held that it is legal for associations to regulate the prices, etc., and for producers to combine to prevent injurious competition and to maintain remunerative prices. A special law, also, provides that should a combination of shippers refuse to transport emigrants at rates approved by the government, their licenses shall be withdrawn. Italy has also established a compulsory cartel of the sulphur producers, as well as a commission for the promotion of the citrus products industry. Among other things, this commission advances money to the producers of citrus products and sells the products, a minimum selling price being fixed each year.

While the civil code of Russia provides that no contract shall be repugnant to the laws, to good morals, or to public order, the Russian government has encouraged the formation of several cartels. The decisions of the courts, however, are not legal precedents; they rather follow the administrative policy. The Russian government has insisted on the formation of a monopoly for the development of its sugar industry; Sweden, for its iron; Roumania, for its petroleum; Greece, for its currants; Brazil, for its coffee; and Mexico, for its sisal fiber.

Japan's commercial code is modeled after the German code; it states that:

> If a business association acts contrary to public order or good morals, the court may dissolve it on the application of the attorney-general, or by exercising its executive power.
>
> If a representative of a foreign business association establishing a branch office in Japan commits any act contrary to the public order or good morals during the management of the business of the association, the court may upon the application of the attorney-general or by its own executive power order the branch office closed.

In China, a person who "unduly depresses or raises prices to suit his own convenience entails a penalty of eighty blows and the undue profit arising therefrom is treated as theft."

Unfair Competition

Unfair competition, according to some French law books, is "an act committed in bad faith with a view of producing confusion between the products of manufacturers or of two merchants, or which without producing confusion causes discredit upon a rival establishment."

In European countries, it relates generally to unfair practices to injure a competitor; the effect on the consumer is not generally considered except as it concerns a competitor. The present tendency, though, seems to be to have a general provision in the civil code that is applicable to the ever varying forms of unfair practices, while several specific laws make the more easily defined or more obnoxious practices illegal and impose the penalties. These special laws are enacted especially where international treaties are concerned or where reciprocity provisions regarding the protection granted foreigners are incorporated in the statutes. Austria, Denmark, Greece, Spain, Portugal, and some of the Swiss cantons are modeled after the laws of Germany. This code provides a special law against specific kinds of unfair competition, which contains also a provision of general application. German jurists generally hold that unfair competition constitutes a violation of the rights which every individual has to his physical and intellectual property. Since 1910, many of the German cities have established boards of arbitration for settling contests on account of unfair competition. These boards are

* An abstract from the bulletin issued by the Department of Commerce, entitled "Trust Laws and Unfair Competition."

Cincinnati Gauging and Inspection Methods

Interchangeability of machine parts is a very flexible term. Even the parts of agricultural machinery are interchangeable, which shows that this word may mean much or little. In machinery construction it must be used in connection with stated or known accuracy limits. The limits to which parts of Cincinnati Millers are made vary from .001″ on some parts to .00025″ on others, and in many cases no tolerance is allowed. When such parts are made interchangeable, the gauging and inspection methods must be rigid.

Gauging Unit Mechanisms—Our unit system of construction demands different gauging methods from those usually employed. Figure 1 shows a set of gauges for testing the alignment of the splined shafts in milling machine knees. This is tested by two indicators, one reading on the top and the other on the side of a master shaft, inserted in the knee. Before making the test, these indicators are set to the master gauges, shown on top of case. This gives us a permanently accurate method of testing, which shows us more closely than any fixed or snap gauge can do whether a shaft is parallel and in its proper position, or in wind and out of position.

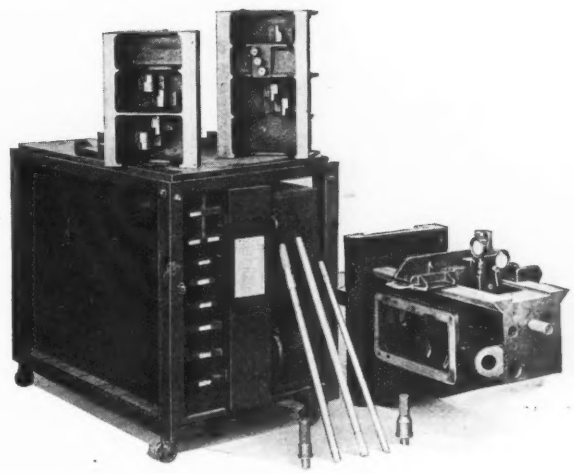

Fig. 1

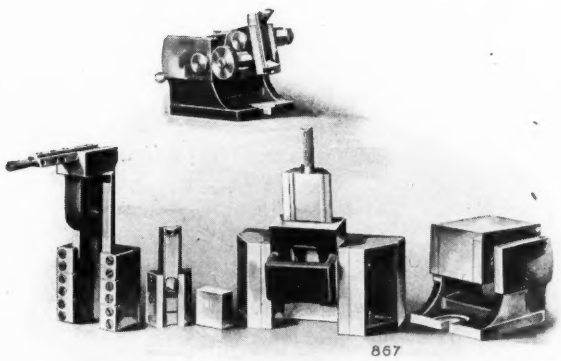

Fig. 2

The Testing Gauges for Our Dividing Head Tailstocks—These tailstocks consist of four parts, all of which slide into each other accurately. These parts are manufactured in lots of fifty. They are absolutely interchangeable in the machining stage, and can be pushed together without any hand work. The final scraping, which merely removes the loose iron, serves to give them a snug sliding fit.

These are only two examples out of many hundreds which we use. You are welcome to inspect these things in our factory at any time.

Let us send you our catalog showing the full line of Millers made by these methods.

THE CINCINNATI MILLING MACHINE COMPANY
CINCINNATI, OHIO, U. S. A.

formed by mercantile associations and do away with much of the expensive and long litigation. They also offer speedy relief from the offense and avoid much distasteful publicity. These boards also have an enlightening influence on the business world regarding fair and lawful competition. They have been especially useful in cases where the decisions of the Imperial Court, in conformity with the letter of the law, were not broad enough and did not keep pace with the progress of current business methods and customs.

According to the French jurists, the relation between a business man and his customers constitutes a commercial property right, and whoever knowingly injures it commits an unlawful act and makes himself liable for damages. They hold that the cardinal principle of unfair competition is intent to injure, and they make a careful distinction between unfair and unlawful competition, based on the existence or nonexistence of wrongful intent. It is unlawful and not unfair competition where a person, in good faith, commits a legal wrong or injures another through negligence or carelessness. But both the French and the German codes agree that the deciding and controlling viewpoint for legislative suppression of unfair competition is not the protection of the public or consumers, but the protection of fellow tradesmen or competitors. In France, actions to enjoin unfair practices and to recover damages because of them are conducted before the tribunals of commerce. These tribunals, of which there are 214, are composed of merchants, and are chosen by the merchants of the district in which they reside. Appeals can be taken from them to the court of appeals.

British laws governing unfair competition, like the laws of the United States, are based largely on the common law. While decisions show that it is sometimes legal for a person to persuade another to break a contract, business competition or competition between union and non-union labor is not a justification for that action. For instance, when a labor union tried to force contractors to comply with its demands by refusing to work on supplies purchased from dealers who sold to them, thus causing them to break their contracts with these dealers, it was held that the dealers injured could recover damages from the members of the union. A similar decision was given by the House of Lords in the case of a union that induced some persons to break their contracts to buy from a man who refused to discharge some non-union men; in this case, the union also induced some of the employes to break their contracts with the man and leave his employ. It was held that some mine owners could recover damages from a union that caused the employes to refuse to work on certain days in violation of their contracts.

Under the Australian laws, unfair competition is presumed if the defendant is a member of a commercial trust; that is, any form of combination to restrict competition. The laws make every attempt to restrict competition or to procure a monopoly *prima facie* evidence of unfair competition. They also term as unfair any competition that will probably result in inadequate remuneration for Australian labor, thus making indirect injury to the employes of a competitor *prima facie* evidence of unfair competition. In order to prevent dumping, the Australian law states that competition is unfair:

> If the methods of importation are considered unfair, or if the importer has purchased the goods imported at prices below the cost of production, or if such goods are being sold at such prices that the importer will not receive a fair profit on the basis of their foreign market value or selling value, if sold in the country of production, allowance being made for freight charges to Australia and customs duties. But in determining whether the competition is unfair, regard must be had to whether the Australian industry is reasonably efficient and up-to-date.

International Agreements

Since the formation of the International Congress for the Protection of Industrial Property, in Paris, in 1878, most of the nations of the world have signed the following: "All the contracting countries agree to assure to the members of the union an effective protection against unfair competition." The Imperial Court of Germany has held that even though an American company had no branch office in Germany, the company was entitled to protection under the terms of this agreement. But it also held that where a British concern had been denied the exclusive use of a trade term in its own country, it did not have the exclusive right to the name in Germany.

In its eighth conference in Budapest, in January, 1914, the Middle European Economic Association formulated plans for making more uniform the laws relating to unfair competition in the various countries. It was also recommended that the several governments enact "uniform legislation for the suppression of such unfair practices as false advertisements regarding quantity and quality, misappropriation and misuse of distinguishing marks for the purpose of enticing customers, disparaging competitors, betrayal or other violation of trust, or spying out business and trade secrets." In the Sixth International Congress of Chambers of Commerce and Commercial and Industrial Associations, which was held in Paris in June of that year, it was recommended "that every nation should make an effort to stop corruption and corruptive practices that affect not only the countries where they are carried on, but also international commerce." It was also recommended that prohibited acts should be made punishable as a crime by the penal code of each country, but that civil prosecution should be allowed, so that the victims of bribery could procure compensation for injuries sustained. D. E. J.

PERSONALS

O. Ericsson, manager of the export department of Nielsen & Winther, Ltd., Copenhagen, Denmark, has come to America for the purpose of buying machinery and tools.

A. L. Buiwitt of Petrograd, Russia, has been given full charge of the New York office of the Russian Metal Trading Co. (Iznosskoff, Suckau & Co.), 149 Broadway, New York City.

Robert K. Greaves, formerly Boston manager for H. Boker & Co., Inc., has been made Western manager for the company, with offices and warerooms at 217-223 N. Desplaines St., Chicago, Ill.

Lester G. French, assistant secretary of the American Society of Mechanical Engineers and formerly editor of MACHINERY, who underwent a serious operation in July, has returned to his duties restored to health.

Albert V. Brouillette, for some time assistant to the chief efficiency engineer of the Remington Arms-Union Metallic Cartridge Co., Ilion, N. Y., is now connected with the New England Westinghouse Co., Springfield, Mass.

Arthur H. Halloran, a well-known electrical man, has been appointed Pacific Coast representative for the Society of Electrical Development. His headquarters will be in the Crossley Bldg., San Francisco, Cal. Mr. Halloran will represent the society in California, Arizona, Nevada, Utah, Idaho, Oregon and Washington.

Franklin G. Hubbard, chief engineer of the mechanical department of the Western Electric Co., Hawthorne, Ill., has resigned to become a stockholder and director of the H. E. Harris Engineering Co. of Bridgeport, Conn. Mr. Hubbard has been elected vice-president, and will have the factory under his supervision.

Swan F. Anderson has disposed of his interest in the Rockford Tool Co., Rockford, Ill., and with his brothers, H. E. Anderson and A. L. Anderson, has started the Anderson Mfg. Co. The Anderson brothers are expert mechanics, and they will make dies, tools, fixtures and special machinery to order. They have acquired a modern plant and are equipped for doing high-grade work.

OBITUARIES

William Bunting, president of the Bunting Brass & Bronze Co., Toledo, Ohio, and an authority on non-ferrous alloys, died August 26, aged sixty-six years. He was born in Belfast, Ireland. He served a seven years' apprenticeship to the brass molding trade in Belfast, and was made foreman two years after serving his apprenticeship. He came to America in 1880, taking a position in Chester, Pa.; from there he moved to Salem, Ohio, to take charge of the brass foundry of the Buckeye Engine Co. Later he moved to Mansfield, Ohio, where he was associated with the Ohio Brass Co. as general superintendent and director of the company. Mr. Bunting remained with the Ohio Brass Co. for sixteen years, during which time the company grew from a small concern to its present large size. He resigned in 1907 to start the Bunting Brass & Bronze Co. at Alliance, Ohio. In 1910 the business of the company outgrew the plant at Alliance and a new plant was erected in Toledo, Ohio—the present location of the company. For the past nine years Mr. Bunting has had his three sons associated with him

One of our NEW customers, who has recently put a

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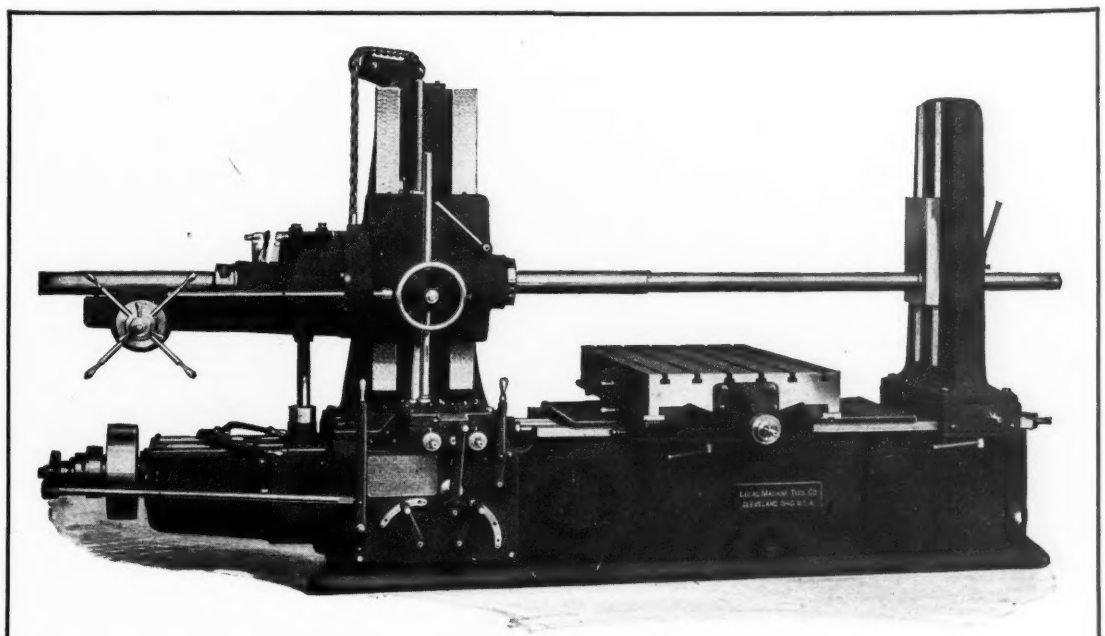
into service, says: "The more I use it the better I like it. If we get into any trouble with THAT machine, it will be our own fault."



We have firmly resisted every temptation to "rush" our product which would inevitably result in lowering QUALITY. The "PRECISION" is made wholly in our own factory, and a machine bought NOW will be made with the same care as in normal times, and will be just as good as any "PRECISION" ever was, unless we find some way to make it better.

LUCAS MACHINE TOOL CO., NOW AND ALWAYS OF CLEVELAND, O., U.S.A.

in business, namely, W. H. Bunting, superintendent; C. E. Bunting, secretary and treasurer; and J. N. Bunting, sales manager. The business will be continued by the three sons.

Mathias Pfatischer, consulting engineer of the Electro Dynamic Co., Bayonne, N. J., died in Roselle, N. J., September 10. Mr. Pfatischer was an electrical engineer and inventor. He invented the electric steering gear with which several Russian battleships and one or two United States cruisers are equipped and also the transatlantic liner *Finland*. He designed and engineered the entire electrical equipment of the *St. Louis* and *St. Paul*, which included several novel electrical features, such as the electric ship telegraph, propeller shaft electrical revolution indicators and electric rudder indicator. He was the originator of the plan of running wires in conduits aboard steamships, etc. He was instrumental in developing a single-phase alternating-current motor, about eighteen years ago, which has proved successful and is known today as the Wagner A. C. motor. In 1904 he invented the inter-pole variable-speed motor which revolutionized the design of direct-current motors, and in 1908 he was awarded the John Scott medal by the Franklin Institute for this invention. Mr. Pfatischer was a member of the American Institute of Electrical Engineers, Electric Power Club, the Technical Society of New York, Franklin Institute and the Elektrotechnische Verein Society of Berlin, Germany. He was with the Electro Dynamic Co. for twenty-seven years.

COMING EVENTS

October 11-21.—New York Electrical Exposition in the Grand Central Palace, New York City. Arthur Miller, director, Irving Place and 15th St., New York City.

October 17-20.—Fifth annual congress of the National Safety Council at Detroit, Mich. W. H. Cameron, secretary and treasurer, Continental and Commercial Bank Bldg., Chicago, Ill.

October 24-25.—Annual convention of National Machine Tool Builders' Association, Hotel Astor, New York City, headquarters. Charles E. Hildreth, general manager, Worcester, Mass.

October 24-27.—Postponed annual convention of the Traveling Engineers' Association, Chicago, Ill., Hotel Sherman, headquarters. W. O. Thompson, secretary, general offices N. Y. C. R. R., Cleveland, Ohio.

October 26.—Monthly meeting of the Rochester Society of Technical Draftsmen, in Rooms 131-137, Sibley Block, 328 Main St., E., Rochester, N. Y. O. L. Angevine, Jr., secretary, 857 Genesee St., Rochester.

November 16-18.—Open conference of the Efficiency Society in New York City. Willis B. Richards, chairman, and M. L. Havey, secretary, 52 Broadway, New York City.

January 6-13.—National Automobile Show in Grand Central Palace, New York City.

SOCIETIES, SCHOOLS AND COLLEGES

Michigan College of Mines, Houghton, Mich. Year book for 1915-1916, with announcement of courses for 1916-1917.

Hebrew Technical Institute, Stuyvesant and 9th Sts., New York City. Catalogue for 1916, containing calendars for 1916 and 1917. Courses of instruction cover English, mathematics, applied science, mechanical drawing, woodworking, wood carving, metal working, engineering and forging, instrument making and electricity. There are also evening classes in toolmaking, instrument making, die making, pattern making, machine work, cabinet making and mechanical drawing.

The Swedish Engineering Convention in the United States, 1915.—Proceedings of the convention, containing a general review of the engineering and social activities, and the papers read at the Swedish Engineering Convention which was held in Chicago, September, 1915. The papers were: "Development of the Swedish Industries," by A. J. Korner; "By-products of the Steel Industry," by A. G. Witting; "Scientific Management and its Practical Application," by A. N. Engblom; "Natural Resources and the Industrial Possibilities of Sweden," by H. F. Sandelin; "Panama Canal, its Construction and Electrical Operation," by E. A. Lof. The proceedings also contain a list of the 290 members of the convention.

NEW BOOKS AND PAMPHLETS

Railroad Master Scales—Specifications and Tolerances. Preliminary Issue, May 20, 1916. Published by the Bureau of Standards, Washington, D. C., in mimeograph form for limited distribution.

Dyke's Automobile Gasoline and Gas Engine Encyclopedia. 824 pages, 6¾ by 9¾ inches. 2370 illustrations. Published by A. L. Dyke, Roe Bldg., St. Louis, Mo. Price, $3.

This book is of the fifth edition, revised and enlarged, containing 366 charts with dictionary and index. It treats of the construction, operation and repairing of motor cars and gasoline engines, and is in truth an encyclopedia of information for the motorist. It deals with the different types of drives, steering, springs, brakes, axles, clutches, change speed gears, engines, valve timing, firing order, carburetion, cooling, lubrication, ignition, magnetos, electric starters and generators, wiring, lighting, storage batteries, car operation, rules of road, insurance, tires and tire repairing, etc.

Practical Safety Methods and Devices. By George A. Cowee. 434 pages, 6 by 9 inches. 128 illustrations. Published by D. Van Nostrand Co., New York City. Price, $3 net.

Gradually the safety movement is coming to be regarded as an engineering matter in industrial organizations. Conceived with altruistic sentiment, it remained for engineers to design and build machinery free from dangerous, unguarded moving parts, to organize means and methods of handling materials, and arrange shops, mills, and factories with a view to promoting production with the minimum danger to life and limb. This work deals with the organization of safety committees, buildings and fire hazards, fire drills, organization of fire brigades, boilers, engines, elevators, electricity, power transmission, machine tools, grinding machinery, woodworking machinery, common machines, handling and storing material, construction work, railroading, mining and quarrying, explosives, etc. Rules for foremen and general rules are included. A chapter is given on sanitation, illumination, heating and ventilating, and another on welfare work, and still another on occupational diseases. The concluding chapter is devoted to first aid to the injured. The work is a very creditable production, well printed and illustrated. It should receive favorable attention of general managers, superintendents, foremen and others responsible for the safe management of shop, mill and factory workers.

Oxy-acetylene Welding. By S. W. Miller. 287 pages, 6 by 9 inches. 192 illustrations. Published by the Industrial Press, New York City. Price, $2.50.

Ten years ago the oxy-acetylene method of welding and cutting metals was hardly more than a laboratory process, but in the course of these few years it has become one of the most important of the methods in the metal-working industries. Much has been published relating to this process, but a great deal of that which has been placed on record in the past has been descriptive of odd jobs. It is, therefore, believed that the present volume, dealing in a more systematic manner with the principles and practice of the art of oxy-acetylene welding, will be of considerable value to those engaged in the metal trades. The information here presented on the subjects of oxy-acetylene welding and cutting has been mainly furnished by S. W. Miller, proprietor of the Rochester Welding Works, whose wide experience in the practical application of the process, and whose success in the work, vouch for the reliability of the information here placed on record. The experience of the author in the oxy-acetylene welding field has been unusually extensive, but having been mostly on repair work, he has written especially for those engaged in a similar line. A great deal of the work done with the oxy-acetylene welding torch is on repairs, and while there are also a great many applications of it in manufacturing work, such applications are more or less special in each case, and sometimes require a great deal of experimenting before success is attained. The general principles here presented, however, apply equally to repair and manufacturing work. This volume describes the equipment required for oxy-acetylene welding and cutting, deals in detail with methods used in welding cast iron, malleable iron, steel, copper, brass, bronze, and aluminum, and gives, in addition, special attention to the welding of sheet metal, tank welding, boiler repairs, etc., as well as to the subject of lead-burning, which is a special kind of autogenous welding.

Automatic Screw Machines. By Douglas T. Hamilton and Franklin D. Jones. 342 pages, 6 by 9 inches. 150 illustrations. Published by the Industrial Press, New York City. Price, $2.50.

This book deals with five distinct branches of automatic screw machine practice. It covers the design and construction of different well-known types of single- and multiple-spindle machines, the tool equipment used for various classes of work, the methods of adjusting or setting-up machines made by different manufacturers, the design of screw machine cams, and the application of machines of this type to both typical and unusual operations. The descriptions of machines are confined principally to the important fundamental features of the design, and deal especially with those mechanisms which control parts that must operate automatically and in accordance with the nature of the work being produced. The machines illustrated were selected as representative types, each embodying important developments in screw machine design. The various types of tools used for turning, boring, recessing, threading, knurling, etc., are described and the methods of applying these tools are illustrated by practical examples. Different attachments are also described, such as are commonly used for slotting screw-heads, milling, cross-drilling, and automatically feeding separate castings or forgings to the machine from a magazine. Information on the adjustment and setting-up of screw machines is given to supplement the general descriptions and show just what changes are necessary when a machine must be arranged for producing different parts. In dealing with the subject of cam design, the exact method of laying out a set of cams for a given operation has been described in detail, in order to clearly indicate the fundamental principles involved. This treatise is intended especially for the users of screw machines and the designers of tools and auxiliary equipment, and, in order to make it of greater practical value to the men responsible for the economical operation of these machines and the production of parts which conform to required standards of accuracy, many different classes of work and a large variety of standard and special tools have been described in detail.

NEW CATALOGUES AND CIRCULARS

Chicago Pneumatic Tool Co., 1060 Fisher Bldg., Chicago, Ill. Bulletin E-43 descriptive of the Duntley universal electric hammer drill.

Aberthaw Construction Co., Boston, Mass. Preliminary report of the Aberthaw investigation of the effects of vibration in structures.

Standard Tool Co., Cleveland, Ohio. Catalogue 22, containing revised price list of taps and dies, which supersedes the prices given in catalogue 20.

Searchlight Co., 415 Karpen Bldg., Chicago, Ill. Circular advertising Searchlight oxy-acetylene welding equipment and illustrating repairs made by this equipment.

Rhodes Mfg. Co., Hartford, Conn. Catalogue of Rhodes vertical and horizontal shapers built in two sizes, 3½-inch vertical and 7-inch horizontal, belt- and motor-driven.

Link-Belt Co., 39th St. and Stewart Ave., Chicago, Ill. Bulletin of "silent chain" drives illustrating chain drive covers for protecting chains and preventing accidents.

Ott Grinder Co., 32 N. Clinton St., Chicago, Ill. Circular giving specifications for the Ott No. 8 plain grinding machine with a capacity of 5 by 12 inches and wheel 10 by 1¼ inch in size.

De Mooy Machine Co., 1833 E. 55th St., Cleveland, Ohio. Circular of the De Mooy sensitive drilling machine made in two sizes, having maximum drilling capacities of 5/16 and 1/2 inch, respectively.

Manufacturers' Appraisal Co., Cleveland, Ohio. Booklet of scientific appraisals covering the appraisal of machine shops, automobile plants, factories, etc. Copies will be sent free upon request.

Montgomery & Co., 104 Fulton St., New York City. "Odds and Ends" No. 4, devoted to jewelers' tools chiefly, many of which are used by machinists, especially toolmakers doing the finer classes of work.

National Machinery Co., Tiffin, Ohio. National Forging Machine Talk No. 14 describes the making of clutch flange and drive shaft forgings for automobile service on National heavy-pattern forging machines.

Nelson-Blanck Mfg. Co., Detroit, Mich. Circular giving specifications for the Nelson two-spindle adjustable drill head, which is made in four sizes, with capacities for drilling ¼, 13/32, ⅝ and 2⅛-inch holes.

De La Vergne Machine Co., 1172 E. 138th St., New York City. Circular advertising the single-cylinder De La Vergne oil engine, type FH, and comparing its operation with that of primitive pumps in use in China today.

Searchlight Co., 415 Karpen Bldg., Chicago, Ill. Catalogue 12 giving specific information on the welding and cutting of metals by the oxy-acetylene process, and illustrating the Searchlight equipment for welding and cutting.

Henry & Wright Mfg. Co., Hartford, Conn. Catalogue of Henry & Wright drilling machines, with from one to eight spindles. These machines are made in two sizes of 8 and 12 inches, and will drive drills of ¾ and 1⅛ inch diameter.

New Jersey Machinery Exchange, 21 Mechanic St., Newark, N. J. Circular of the "Production" hand surface grinder. The machine, which has a platen 5 by 15 inches and a traverse of 8 inches, uses grinding wheels ⅛ inch by 6 inches.

Clarage Fan Co., Kalamazoo, Mich. Catalogue of Clarage multi-blade fans, containing capacity tables for the various sizes and styles, taken from actual performance tests, made with temperature of 70 degrees F. and barometric pressure of 29.92 inches.

Excelsior Needle Co., Torrington, Conn. Catalogue descriptive of the Dayton swaging machine, illustrating its construction and some of the work for which it is adapted. Dimensions and capacities of the various machines included in the line are given.

Stow Mfg. Co., Binghamton, N. Y. Bulletin 100, illustrating and describing Stow electric motors.

If Boasting A Bit Is Pardonable

1915 and 1916 have done much for us in the way of new customers. We have added more new names to our books than the total of many previous years; and names of the highest possible quality.

Due in part to good business generally, but in a very large measure due to our exceptionally large stocks; large both as to *quantity and variety!*

While it is common knowledge that certain classes of staples (notably, in the tool line, drills and files) are alarmingly scarce, yet our output has more than doubled our biggest years.

In placing your orders for a general line of factory needs, particularly your wants in the way of screws, bolts, nuts, rivets, etc., and all manner of machinists,' carpenters' and hand tools in general, it might be well to consult our large catalogue and correspond with us before "signing up" elsewhere. You can easily judge if the comparison be favorable.

HAMMACHER, SCHLEMMER & CO.

HARDWARE, TOOLS AND SUPPLIES

New York, Since 1848 **4th Avenue and 13th Street**

Bulletin 101 of electric tools, including portable drills, buffers and grinders, "Gee Whiz" machines, screwdrivers, etc. Bulletin 102 of flexible shafting, illustrating various applications.

Foxboro Co., Foxboro, Mass. Bulletins 95, 97, 98, 101, 102 and 103, treating of Foxboro indicating gages, counters and clocks; syphon and mercurial gages; recording gages; radial planimeter; mechanical and electrical time recorders; recording hygrometers or wet and dry bulb thermometers, respectively.

Brown & Sharpe Mfg. Co., Providence, R. I. Catalogue 27 of small tools, comprising micrometer calipers, steel rules, machinists' squares, combination squares, bevel protractors, straightedges, vernier calipers, screw pitch gages, surface gages, thickness gages, standard reference disks, limit gages, wire gages, indicators, spring calipers, milling cutters, etc.

Simonds Mfg. Co., Fitchburg, Mass. Booklet entitled "How to File a Hand Saw," containing information pertaining to the construction and operation of hand saws and the correct method of filing, as well as suggestions on the care of hand saws. Some of the Simonds hand saws are illustrated, for which dimensions and prices are given.

W. S. Rockwell Co., 50 Church St., New York City. Catalogue 31, treating of fuel oil appliances and the fundamental principles which govern the handling and burning of fuel oil. The catalogue illustrates installations of oil-fired furnaces, as well as the line of Rockwell oil and gas burners, fuel oil pumps, blowers, oil strainers, air pressure gages, etc.

New Jersey Foundry & Machine Co., 90 West St., New York City. Catalogue 88, describing the line of hand and electric cranes, monorails, trolleys, hoists, etc., made by this company. Tables containing prices are also included. The book illustrates a number of installations of cranes and other overhead carrying devices in various manufacturing plants.

Munning-Loeb Co., Matawan, N. J. Booklet of the "Safety" buff, polishing and grinding wheel balancing washer, which does away with the hazardous method of balancing by attaching pieces of lead, nails and screws to the light side of a wheel, and enables the operator to balance a wheel perfectly in a very short time. Copy of the booklet will be sent free upon request.

Lincoln Electric Co., Cleveland, Ohio. Catalogue of Lincoln induction motors for two- or three-phase alternating current. The bulletin describes in detail the rotor and stator construction, waterproof and dustproof insulation, and other features. Illustrations show a number of applications of these motors in chemical and paint factories, wood-working plants, bakeries, provision and packing plants, foundries, metal-working plants, etc.

Cincinnati Chamber of Commerce, Cincinnati, Ohio, has begun the publication of "O Cincinnatian" in Portuguese for distribution in Brazil, Portugal and the Portuguese possessions with a view of advertising Cincinnati and her industries. The first number is profusely illustrated with views of Cincinnati's buildings, streets, parks, bridges, etc. The new publication is in charge of A. S. Wilson, manager of the foreign trade department.

Detroit Tool Co., Detroit, Mich. Catalogue of semi-automatic drilling machines and pumps. These horizontal drilling machines are designed specifically for drilling small holes in small work. They are equipped with five spindles and are made in two sizes, the No. 1 machine being designed for very small high-speed work, and the No. 2 machine for a little larger work. Some of the work drilled on these machines is illustrated, and includes valves, small screws, keys, cotter-pins, etc. A table gives the diameter and depth of hole, material drilled, and pieces turned out per hour.

Buckeye Engine Co., Salem, Ohio. Catalogue of power presses formerly made by the Cleveland Machine & Mfg. Co. The catalogue gives dimensions for this line of presses as well as for the Cleveland shears, bending rolls, dies, etc. The Cleveland presses are built in many types and sizes, classified as follows: open-back inclinable presses, punch presses, straight-sided single crank presses, straight-sided double crank presses, gap frame single crank presses, gap frame double crank presses, horning presses, wiring presses, screw presses, knuckle joint presses, cam drawing presses, toggle drawing presses, and notching presses.

Fitchburg Automatic Machine Works, Fitchburg, Mass. New catalogue devoted to the "Radical" automatic multiple-spindle screw machine. The book contains illustrations of the pan, bed, tool-head, cylinder and cross-slide carriage, indexing mechanism, spindles, cams, gage stops, spindle gearbox, oil system and tools, together with the necessary descriptive matter of the salient features of construction. The make-up of the book represents a departure from the conventional form of catalogue. It is bound in imitation wood covers and printed on brown paper, with display type in green. The illustrations are printed separately and pasted on the pages.

Imperial Brass Mfg. Co., 1224 W. Harrison St., Chicago, Ill. "Imperial" welding and cutting handbook treating of oxy-acetylene and oxy-hydrogen welding and carbon burning. This handbook is distributed free to purchasers of Imperial equipment, and to all others the price is $1. The book describes the principles of welding and the operation of the "Imperial" welding outfit. The allowance for expansion and contraction in welding is taken up, as well as preheating agencies, regulation of the flame, preparing the work for welding by beveling or chamfering, and other essential data. The welding of different kinds of metal is treated and information is given on figuring costs. The "Imperial" oxy-acetylene equipment, including welding and cutting torches and oxy-acetylene regulators, is illustrated. The book should be of considerable value to all users of oxy-acetylene equipment.

Diamond Chain & Mfg. Co., 240 W. Georgia St., Indianapolis, Ind. Catalogue of roller chain and sprockets, which also comprises a treatise on chain driving. A new form of sprocket tooth known as the "Diamond tooth form" for roller chain sprockets has been developed by the company, and the advantages of this tooth are set forth in the new catalogue. It is claimed that this new tooth form results in quieter action and longer life for both chain and sprocket. The catalogue treats of the design of roller chains and sprockets, and gives formulas for the calculation of chain lengths, center distance for chain with no slack, pitch diameters, outside diameters, horsepower, chain velocity, sprocket speed, chain pull, maximum allowable pitch and maximum allowable revolutions per minute. A table of useful data for Diamond chain drives is also included. The problem of the selection of proper chain and sprockets for given conditions is worked out and discussed, illustrating the formulas in a clear manner. This book will be sent without charge to engineers, designers and officials.

Hendey Machine Co., Torrington, Conn. Catalogue of Hendey engine lathes, describing in detail the various parts, including the quick-change gear equipment, tie bar headstock, spindle and bearings, double-wall safety type apron, carriage reversing mechanism, automatic stop for carriage, etc. These lathes are submitted to careful tests before shipment, and illustrations show testing the alignment of the spindle, testing cross-slide alignment, testing tailstock spindle and testing the lead-screw. Specifications are given for lathes of 12-, 14-, 16-, 18-, 20- and 24-inch sizes. Geared-head lathes of the same sizes are also illustrated and specifications given. In order to meet the demands of foreign trade, the company provides all sizes of its lathes with metric pitch lead-screw and special gearing when ordered. The catalogue also illustrates various operations performed by means of the relieving attachment, among which are relieving spiral fluted hobs and taps, relieving form cutters, inside relieving, relieving sides of angular cutters, relieving counterbores, etc. Definite information for determining pitch of spiral, selecting gears, etc., for these operations is included. Tool-room equipment for use with Hendey lathes is illustrated, and the line of geared-head lathes equipped with electric motor drive is also shown. This catalogue is unusually comprehensive, well illustrated, and contains much valuable information for lathe users.

TRADE NOTES

Chicago Nut Co. has moved into its new building, located at 2513-2539 W. 20th St., Chicago, Ill., to which address all mail should be sent.

Brown & Sharpe Mfg. Co., Providence, R. I., has opened an office in Pittsburg, Pa., in the Henry W. Oliver building. J. F. Lyon is in charge.

Greenfield Tap & Die Corporation, Greenfield, Mass., manufacturer of screw cutting tools and machinery, gages and reamers, has discontinued its store in Detroit, Mich.

Elgin Tool Works, Elgin, Ill., makers of the Elgin precision bench lathe and special machinery, will erect a large addition to their plant at once, which will double the present capacity.

Munning-Loeb Co., Matawan, N. J., manufacturer of electro-plating and buffing apparatus and supplies, has removed its New York office from 417 Canal St. to the Taylor Bldg., 39 Cortlandt St. The office is in charge of G. C. Backus.

Sleeper & Hartley, Inc., Worcester, Mass., states that the heavy spring coiler which was illustrated and described in the July number of MACHINERY was shipped to France, and was sold through Edgar Bloxham, 12 Rue Du Delta, Paris.

Rockford Iron Works, Rockford, Ill., makers of punch presses, have completed a large addition to their machine shop, which more than doubles the present capacity. It is hoped that this additional facility will enable the company to catch up with its orders.

New Britain Machine Co., New Britain, Conn., gave an outing to its employes at Cosey Beach, Conn., September 19. In addition to paying all expenses of the excursion, including transportation, dinner, music, prizes, etc., the company allowed the men their regular day's pay. An attractive program was printed covering all events and giving the names of competitors, etc.

Rub-On Mfg. Co., Inc., 87-97 Brayton St., Buffalo, N. Y., has changed its name to the Ellis-Smith Mfg. Co., Inc. The management and sales policy will be changed in no way. The change of name was made because the original name no longer applies to the products now manufactured by the company, which are automobile turntable jacks, towing trucks and valve reseating tools.

Crocker-Wheeler Co., Ampere, N. J., announces that its San Francisco district office has been removed from the Crossley building, 619 Mission St., to the ground floor of 87 New Montgomery St. A large assortment of motors, generators and transformers will be carried in stock for the convenience of buyers of electrical equipment on the Pacific coast. W. K. Brown is district manager.

Steel Improvement Co., Cleveland, Ohio, has purchased the plant of the Forest City Forge Co. The two companies will be reorganized under the name of the Steel Improvement & Forge Co., and the manufacture of automobile forgings will be added to the heat-treating business. The officers are W. E. Byrns, president; George H. Chandler, vice-president; W. C. Whyte, secretary; and R. R. Abbott, engineer.

Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., has recently received an order from the Pennsylvania Railroad Co. for a 20,000-K.W., 11,000-volt, 25-cycle, turbine unit, complete with a 24,000-square foot surface condenser and auxiliaries. This turbine is for installation in the railroad company's Long Island City power house which supplies power for the operation of the Pennsylvania terminal and the Long Island railroad.

J. N. Lapointe Co., New London, Conn., gave an outing to its employes August 26, in which over 200 of the workmen and also other guests participated. Early in the day, a large American flag was presented to the president, J. N. Lapointe, by the employes, the presentation being made by J. L. Wheeler. Mr. Lapointe promised the employes that at the completion of the four-story addition now being built on Pequot Ave., the flag would decorate the new building on appropriate occasions.

Imperial Brass Mfg. Co., 1224 W. Harrison St., Chicago, Ill., manufacturer of oxy-acetylene apparatus, reducing valves and brass specialties, has begun the construction of an addition that will increase the floor space 75,000 square feet, making the total floor space of the plant 150,000 square feet. The new building, like the old, will be of heavy mill construction, and will be located on the site adjoining the present plant, corner Harrison St. and Racine Ave., near the "Loop" district.

Sutherland Tool Co., 723 Ann Arbor St., Flint, Mich., is the new name of the Flint Tool Salvage & Machine Co. The company specializes in recutting milling cutters without annealing them. The change of name was made because of the confusion arising from the similarity of name to that of another concern engaged in the same work. The Sutherland Tool Co. has removed its cutting department, which has been run in connection with the machine shop, to a new shop recently completed.

Armstrong Bros. Tool Co., 313 N. Francisco Ave., Chicago, Ill., is building a steel and brick addition to its drop-forging department 50 by 70 feet and a reinforced concrete fireproof building 60 by 130 feet, four stories, to be used for finished stock warehouse, shipping department and offices. These buildings, with the new machinery and equipment to be installed, will largely increase the company's facilities for taking care of its rapidly increasing business. The constantly growing demand for Armstrong tool-holders has made the increase of facilities imperative.

Brennan Engineering Co., 36 W. Randolph St., Chicago, Ill., has been incorporated under the name of Brennan Wahl Co., as mechanical, structural and chemical consulting engineers, and will act as manufacturers' sales and purchasing agents for machinery and allied products. The president is Daniel A. Brennan, patent attorney and designer of labor-saving machinery. Henry R. Wahl, the secretary-treasurer, was formerly construction engineer with the St. Joseph Lead Co., and Andrew G. Schneider, the vice-president, was formerly manager of the Sherardizing Co., of Chicago.

Gronkvist Drill Chuck Co., 20 Morris St., Jersey City, N. J., has moved to the fifth floor of the Locomobile building, 22 W. 61st St., New York City. In the new quarters the concern will have more space to meet the requirements of its growing business in the manufacture of gages. The company has recently been incorporated for $100,000, and is now known as the Swedish Gage Co., Inc. The officers of the company remain the same, and there will be no change in the product or policies. The new name was adopted as being more suitable to the business than the old.

H. E. Harris Engineering Co., Bridgeport, Conn., announces that Franklin G. Hubbard, chief engineer of the mechanical department of the Western Electric Co., Hawthorne, Ill., has become a stockholder and director and has been elected vice-president. Harry E. Harris will devote his entire time to engineering work and the commercial end of the business. In addition to the engineering business connected with the company's special machine tool and gage work, it makes taps, dies, thread gages, ring and plug gages, the Harris precision tapping machine, automatic grinders and notching machines.

CLASSIFIED AND WANT ADVERTISEMENTS

Will be found on page 329 of this issue and will be run in the same relative position in future.